PROBOSCIDEA

HENRY FAIRFIELD OSBORN

World Distribution of I. Moeritheres

I ◆ *Moeritheriinae*

II ◘ *Deinotheriinae*

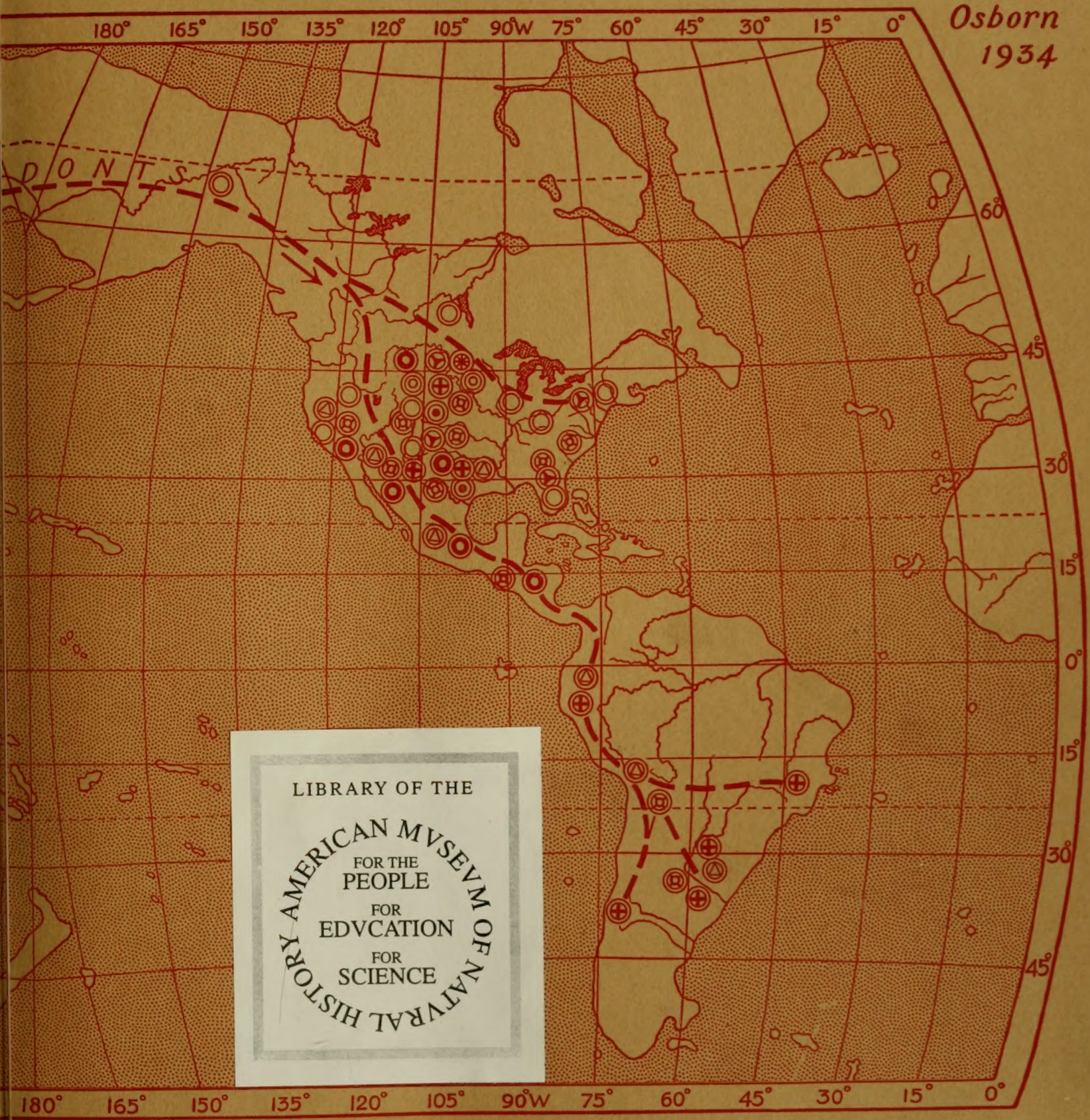
III ◎ *Mastodontinae*

" ⊕ *Zygolophodontinae*

" ▽ *Longirostrinae*

" ◎ *Amebelodontinae*

II. Deinotheres III. Mastodonts



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III ◎ *Tetralophodontinae*
" ◎ *Serridentinae*
" ◎ *Platybelodontinae*
" ◎ *Rhynchorostrinae*

III ◎ *Notorostrinae*
" ◎ *Humboldtinae*
" ◎ *Brevirostrinae*

D.F. Levett Bradley

PROBOSCIDEA

This original edition (issued August 15, 1936)
is limited to six hundred and seventy-five copies,
of which this is Number 40

RESTORATION OF THE WARREN MASTODON (*MASTODON AMERICANUS*)
After a painting by Charles R. Knight in 1908, under the direction of Henry Fairfield Osborn

This restoration is based on the classic skeleton known as the Warren Mastodon, which was unearthed in the year 1845 just north of the Highlands of the Hudson and presented by the late J. Pierpont Morgan to the Hall of the Age of Man of The American Museum of Natural History in the year 1906. The animal took its name from John C. Warren, Professor of Anatomy at Harvard University, who described it in detail in his memoirs of 1852 and 1855.

The painting represents the animal, a bull at least thirty years old, as he appeared in life before he sank into a shell-marl basin six miles northwest of Newburgh-on-Hudson, New York; this event, so auspicious to palæontologists of today, occurred in the Late Glacial Epoch between 30,000 and 40,000 years ago. In the right background is the north gap in the Hudson River Highlands, Storm King Mountain on the right and Break Neck on the left. In the foreground is one of the shallow sheets of water covering the shell-marl in which the remains of the animal were so perfectly preserved. The flora of the forest corresponds with the description by Asa Gray, in a letter to Doctor Warren, of the contents of the mastodon's stomach: "An examination with the microscope showed, from the structure of the woody fibre, that they were boughs of pine or spruce of some sort, and that they minutely agreed with the wood of hemlock spruce; so that this is very probably the species they belonged to, but there is no certainty of it."

PROBOSCIDEA

A MONOGRAPH OF THE DISCOVERY, EVOLUTION, MIGRATION AND EXTINCTION OF THE MASTODONTS AND ELEPHANTS OF THE WORLD

BY

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EDITED BY MABEL RICE PERCY

VOLUME I

MŒRITHERIOIDEA

DEINOTHERIOIDEA

MASTODONTOIDEA

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PUBLICATION NOTE

Volume I has been on the American Museum Press since 1924. In the course of the intervening eleven-year period to 1935 the field of research has been greatly broadened and many discoveries have been made which alter the Classification of the Proboscidea; the consequent alterations appear in the Table of Contents and in the Phylogenetic Appendix to the present volume.

At the time of the author's lamented death on November 6, 1935, the final revision of the manuscript was in progress. This has been carried out along the lines laid down by him; since that time no changes have been made in his determinations and necessary corrections have been inserted as footnotes.

Volume II, containing Elephantoidea, Appendices, and Index, will be issued as soon as possible, probably in 1937.

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IN MEMORIAM

IOANNIS PIERPONT MORGAN

ARTIVM ET SCIENTIARVM

ADIVTORIS ARDENTIS ET LIBERALIS

HOC VOLVMEN

AMICITIAE MNEMOSYNVM

D. D. D.

SCRIPTOR

During the Years 1907 to 1936

The Explorations, Collections, Researches and Printing of this Monograph

Have Been Promoted Chiefly by Funds Donated by

JOHN PIERPONT MORGAN

1837 — 1913

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PREFACE

THE author began his researches for this Monograph by devoting the years 1889–1900 to zoogeographical research on the origin, migration and distribution of the twenty-two Orders of Mammals known at that time. The theoretic conclusion was reached that the Proboscidea originated in Africa. This conclusion was confirmed in the Fayûm district of northern Africa by Hugh Beadnell (1901–4) and by Charles William Andrews (1901–3). In Andrews' Memoir of 1906 published by the British Museum (see p. 36 of the present monograph) he wrote:

> The probability that Africa would be found to be the original home of these animals was pointed out by several writers, notably Osborn, Stehlin, and Tullberg. The first of these suggested that probably not only the Proboscidea but also the 'Hyracoidea, certain Edentates, the Antelopes, the Giraffes, the Hippopotami, the most specialized Ruminants, and among the Rodents the Anomalures, the Dormice, and Jerboas, among Monkeys the Baboons,' and, as his map suggests, the Sirenia also, originated in this region. Osborn also put forward the theory that a succession of migrations from Africa to Europe occurred, notably at the end of the Eocene, at the beginning of the Miocene, and again in the earliest Pliocene. It was in the early Miocene migration that the Proboscidea passed out of Africa for the first time so far as known.

The American Museum expedition of 1907 amplified the epoch-making discoveries of Beadnell and Andrews and subsequent exploration has demonstrated beyond question that in Africa originated not only the Mœritheres and primitive Mastodonts but also the Deinotheres and the Elephants. Not a trace of these proboscideans has been found in any other continent earlier than Miocene time, when waves of Deinotheres and Mastodonts, already highly specialized, began to enter Eurasia and to migrate to all the continents excepting Australia.

The actual preparation of this monograph opened in the year 1907 with the author's expedition to the desert bordering the Fayûm of northern Egypt, accompanied by Walter Granger of the mammalian palæontology staff of the American Museum. In 1908 the author determined to give the Proboscidea a monographic treatment similar to that he was then giving to the Titanotheres. Intensive work on the Proboscidea, first entered upon in 1920 during the concluding phases of work on the Titanotheres, has continued without interruption for fifteen years. Thus the intensive study of the evolution and phylogeny of two dominant and widely different types of mammals, the Titanotheres and the Proboscideans, has occupied a total uninterrupted research period of thirty-five years, 1900–1935.

The Titanothere Monograph involved methods of collateral research in geology, comparative anatomy, animal mechanics and biology that were largely new to the science of palæontology, chiefly in the science of measuring the skull (craniometry) and in the science of animal ascent (phylogeny). From the outset the craniometric methods and results of the Titanothere researches partially prepared the way for the solution of proboscidean problems. In their adaptations the Proboscidea present the widest possible contrasts to the Titanotheres. Moreover, there was little conception of the new and rapidly oncoming difficulties in interpreting the classic proboscideans as a whole or the entirely unexpected adaptations in numerous new lines of mastodont and elephantoid ascent. Previously undreamt-of kinds of proboscideans have been discovered. Through the classic and the new kinds have been revealed a number of biological principles hitherto unknown.

METHODS OF COMPARATIVE RESEARCH

In the analysis and synthesis of thousands of observations on the Proboscidea it soon became obvious that five main lines of research were essential to a judicial, comprehensive and philosophical treatment:

First, to survey, for the restatement of historic descriptions and figures, the ancient literature of what may be called "the dawn period" of mammalian palæontology, including Robert Kerr's naming of the American mastodon, *Elephas americanus*, in 1792 and Blumenbach's naming of the European mammoth, *E. primigenius*, in 1799; second, to study all the subsequent scientific descriptions of fossil and living proboscideans, with republication of essential parts of the original descriptions and reproduction of all the original figures; third, to directly or indirectly reëxamine all the fossil proboscidean collections in the world and especially to verify and refigure all types of genera and species; fourth, to secure the coöperation of mammalian palæontologists all over the world in the examination of distant collections inaccessible to the author; fifth and most important, to approach this great and difficult subject with an entirely open mind, unbiased by preconceptions, each problem to be considered in a fresh and free spirit of observation, induction and generalization.

Thus approached, *the Proboscidea have proved infinite in variety, full of surprises, creative of new ideas and demonstrative of new evolutionary principles.*

DISCOVERY OF MULTIPLE LINES OF PROBOSCIDEAN ASCENT

A research period of unparalleled difficulty proved to be also a period of unparalleled opportunity—opportunity such as has never before been afforded to any zoologist, palæontologist or biologist. There has been vast expansion of our knowledge since the year 1859 in which appeared Darwin's "Origin of Species," since 1886 when Richard Lydekker catalogued the Proboscidea in the great collection of the British Museum (Natural History), and even since 1929 when D. M. S. Watson's article, "Proboscidea," appeared in Volume XVIII of the Fourteenth Edition of the Encyclopædia Britannica. Even within the year 1935 most surprising discoveries have been made bearing on the origin and distribution, affinity and ascent of the Proboscidea, which as far as possible are embodied in the phylogenetic appendix at the close of the present volume.

The outstanding result of the expansion of our knowledge of the Proboscidea is the demonstration, partly in fulfilment of the prophetic vision of Hugh Falconer, that the single genus *Mastodon* of Cuvier is the prototype of the suborder Mastodontoidea, which comprises all the mastodonts of the world, as fully set forth in the Appendix. This suborder embraces thirty-one distinct lines of generic ascent—in brief, of genera; these genera are grouped into fifteen distinct subfamilies, which in turn are grouped into four families, out of one of which it is possible that the Elephantoidea, the second great suborder of the Proboscidea, evolved.

In like manner, as fully set forth in Volume II, the single genus *Elephas* of Georges Cuvier is now known to have divided into eight to ten separate lines of generic ascent, which in turn are grouped into four subfamilies, actually very wide apart in structure, in geographic distribution, in feeding habits and in adaptation. None of these elephantoid lines is known prior to Middle to Upper Pliocene time. The line with the most noble geologic and geographic history is that of the genus *Archidiskodon*, which apparently dated back to the Middle Pliocene of South Africa and enjoyed a glorious migration of 15,000 miles to its Late Pleistocene climax in Nebraska, Texas and Mexico.

Thus, taken altogether, the Mastodonts and the Elephants, the Deinotheres and the Mœritheres—the four great branches constituting the great order PROBOSCIDEA—are now known to have evolved along no fewer than forty-one lines of generic ascent.

LINNÆAN CLASSIFICATION REPLACED BY OSBORNIAN

The above revolution, by the discovery of multiple lines of ascent, is first manifested in the zoologic and classificatory treatment of the Proboscidea, in which we are impelled to substitute for the purely zoologic pre-evolutionary classification of Linnæus an evolutionary or phylogenetic classification based on principles first set forth by the author in 1892 and fully exemplified in the Titanothere Monograph (1929). Inherent in phylogenetic classification are entirely new conceptions of the real evolutionary meanings of the old Linnæan terms Species and Genus, Family and Order, as well as of the more recent terms Superfamily, Subfamily, Subspecies and Mutations. The classic Linnæan system based solely on zoologic observation and the creational concept is now replaced by a phylogenetic system in which all divisions from the Subspecies to the Order are placed vertically as succeeding each other during millions of years of geologic time, rather than horizontally as observed in recent or existing time by Linnæus and all zoologists.

The Osbornian phylogenetic system that was set forth in the Titanothere Monograph (Vol. I, Fig. 14, p. 16) is literally fulfilled in one proboscidean family known as the Serridentidæ, embracing seven complex lines of ascent of the serridentine mastodonts, namely, *Serridentinus*, *Ocalientinus*, *Serbelodon*, *Trobelodon*, *Platybelodon*, *Torynobelodon*, *Notiomastodon*; also in an elephantoid subfamily known as Mammontinæ, embracing three related but widely distinct kinds of mammoths—the woolly, the hairy, the southern—*Mammonteus*, *Parelephas* and *Archidiskodon*. Thus for the first time we arrive at the real evolutionary significance of the classificatory terms of Linnæus—Order, Suborder or Superfamily, Family, Subfamily, Genus, Species, Subspecies, Ascending Mutation.

The facts upon which these phylogenetic results of mastodontoid and elephantoid ascent are established may be summarized as follows:

1) The Proboscidea originated exclusively in Africa, probably in Upper Cretaceous or Lower Eocene time.

2) Not remote from the stem that gave rise to the manatees and dugongs (Sirenia), proboscideans were distinguished from the first by specialization of the second incisor teeth above and below, also by the potentiality of forming transverse ridge-crests which, especially in the third superior and inferior grinders, rise from primitive 2½–3 ridge-crests to progressive 30 ridge-crests.

3) The subfamily radiation into all habitats, from the purely aquatic and amphibious habitat of the Mœritheres to swamp, river-border, shallow lake-border, savanna, forest, tundra and desert habitat, from humid to arid climates, from equatorial to boreal latitudes and from sea level to elevated mountains (for example, the Andean mastodon), in which thirty-one lines of mastodonts and eight to ten lines of elephants have become specialized in every organ.

4) The conversion of a broad prehensile upper lip of the hippopotamus type in the Mœritheres into the broad prehensile upper lip of many of the mastodonts and, finally, into the true proboscis of certain mastodonts and of all Stegodonts and elephants.

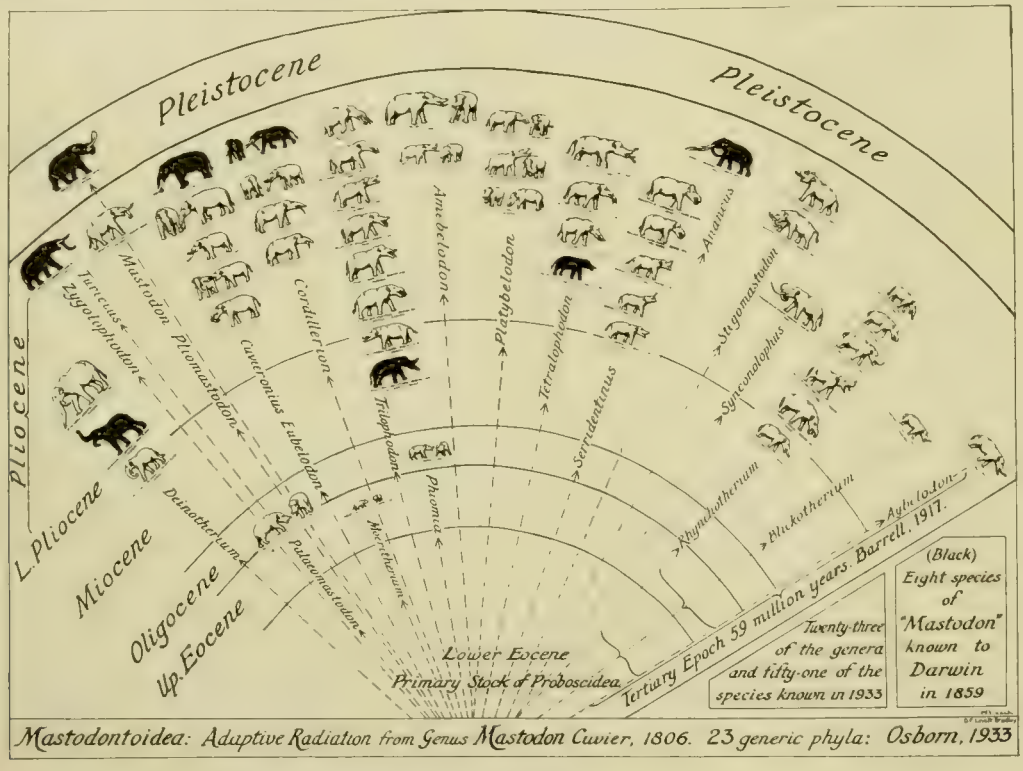
5) The genera are primarily distinguishable (a) by the adaptations of the grinding teeth which, when very carefully analyzed, as in the Appendix to the present volume, are highly characteristic, and (b) by the respective adaptations of the superior and inferior incisive teeth to a great variety of proboscidean floral habitats and modes of feeding; (c) in the Deinotheres, in three kinds of shovel-tuskers, also in the Rhynchotheres, the lower incisive tusks are far more important and diversified than the upper, while in many mastodonts and in all the Stegodonts and elephantoids the lower tusks disappear entirely, the lower jaw being correspondingly abbreviated; (d) the superior tusks function first as offensive weapons of marked sexual variation and second as auxiliary feeding tools of great importance, excepting in one division of the elephantoids in which the gigantic superior tusks are withdrawn from feeding service and become only of sexual distinction and value.

6) There is consequently frequent recurrence of adaptive parallelism, namely, of similarly specialized organs, like the shortened jaw being independently produced in different phyla, or the rounded and upturned enamel-less superior tusks serving as weapons.

7) With the various functions and forms of the superior and inferior grinders, the superior tusks, the upper lip and the proboscis are coördinated not only the cranium and jaws but also the neck, backbone, and limbs. For example, the three types of mammoths—the tundra (*Mammonteus*), the north temperate (*Parelephas*) and the southern (*Archidiskodon*)—alike exhibit enormous incurved tusks of use only in combat or for sexual selection purposes and not as auxiliary feeding organs; in these three mammoths the posterior half of the backbone is relatively weak because the tusks have relatively little work to do as auxiliary feeding organs, whereas in the African and Indian elephants and their relatives the backbone is extremely strong, in correlation with active tusks.

PROBOSCIDEA, THE NEW STANDARD OF CHRONOLOGIC WORLD CORRELATION

Not revolutionary, but in accord with the clocking of geologic time by similar stages of evolution (homotaxis, Huxley) long in use by invertebrate palæontologists, is the evidence yielded by intensive examination which the Proboscidea afford for Tertiary geologic correlation of stages in adaptive progression and retrogression in the widely distant distribution centers of mastodonts and elephants which migrated into all the continents except Australia. The continuous evolution of far-separated adaptations of the grinding teeth, in northern and southern Africa, in Eurasia and in North and South America, can now be coördinated with unexpected precision, as in the outstanding metamorphosis of *Archidiskodon proplanifrons* of South Africa into the gigantic *Archidiskodon maibeni* of Nebraska (see Volume II). In this correlation the intensive study of the grinding teeth in the mastodontoid and elephantoid divisions plays a leading part.



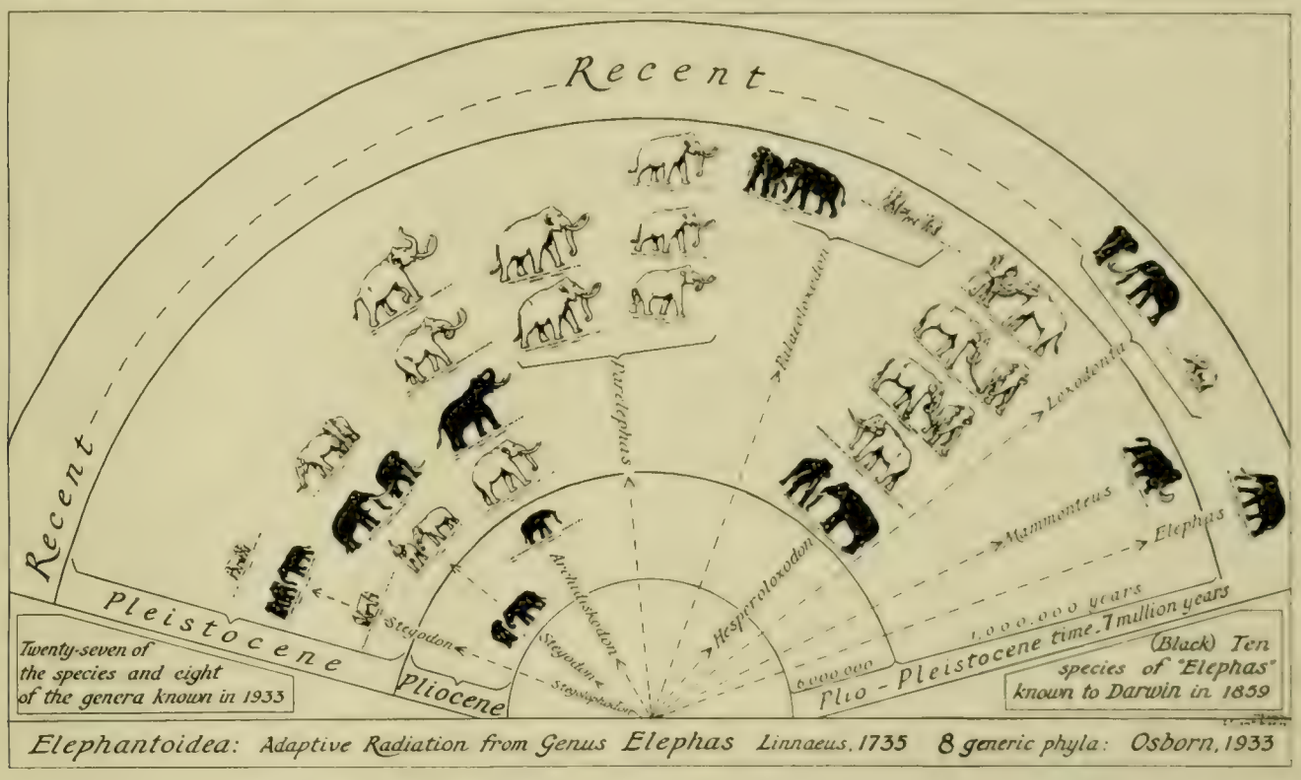
PROBOSCIDEAN CHRONOLOGY

Another result which will prove to be revolutionary in anthropology is the new means afforded of dating precisely the main periods of the prehistoric evolution of Man, by intensive measurement of the length, width and thickness of the enamel layers in the grinding teeth of the elephantoid division (Osborn 1931.858) in successive stages from Upper Pliocene to closing Pleistocene time. Man was a mastodon and elephant hunter from early times. Remains of fossil elephants are occasionally found embedded in the same strata with remains of fossil man, and the total length of the enamel foldings in proboscidean grinding teeth enables us to date relatively the successive phases in the evolution of man.

ARISTOGENESIS AND PROPORTIONAL MODIFICATION

From the author's prolonged thirty-five-year research on Titanotheres and Proboscidea there issue not only the principles governing the classic modifying modes of evolution known to Lamarck and Darwin (variation, development, degeneration) but also the newly discovered and hitherto unrecognized principle and modes of the origin of new characters through aristogenesis or creative biomechanical rectigradation (Osborn 1894.92,1934.922).

Ascending mutations, species and genera are principally defined by continuously progressive changes in the aristogenes and proportions of the grinding teeth and in the upper or lower incisive tusks. Although the rate of proportional adaptation varies enormously, for the first time we know approximately how long a period of geologic time it takes to produce a full-fledged and highly efficient adaptation, as in the metamorphosis of the lower incisive tusks of Oligocene *Phiomia* into the dominant shovel-tusks of Pliocene *Amebelodon* (see Plate V, pp. 236–237), or in the metamorphosis of the posterior grinders of *Trilophodon* from Lower Miocene into Mio-Pliocene time (see Fig. 300, p. 341).



PRINCIPLES OF ADAPTIVE PROBOSCIDEAN ASCENT

Through the clear distinction between change of proportion (alloiometry) and the origin (aristogenesis) of new parts, also through the newly discovered multiple lines (forty-one or more) of ancestry and ascent technically known as phyla, the Proboscidea afford a complete revolution in our biological philosophy and concepts of the nature and causes of evolution. The contrast between Darwin's knowledge of the Proboscidea when he wrote the *Origin of Species* in the year 1859 and the knowledge contained in this monograph is graphically shown by comparing the two accompanying charts (1933) with Plate XI (1935).

Never before has it been possible to follow many lines of phylogenetic ascent over extremely long periods of geologic time, noting the progressive adaptive changes in each organ in each phylum to gain the perfection of certain mechanisms at the expense of other mechanisms. In general, the specialization of certain organs becomes more intense, while closely contiguous organs remain absolutely stationary. For example, among the shovel-tuskers, *Phiomia osborni* of the Oligocene of Egypt gives rise to the incredibly specialized *Amebelodon fricki* of Nebraska, with a relatively similar and unchanging skeleton and limbs. *Amebelodon* is paralleled by the flat-tusker *Platybelodon* of the Gobi Desert and of Nebraska in which the whole jaw becomes an enormous shovel, the upper jaw and skull being sacrificed and thus greatly reduced in size.

[*This section of the Preface was not completed by the author.—Editor.*]

ACKNOWLEDGMENT OF COÖPERATION

Coöperation in the preparation of this monograph has been practically worldwide, with the exception of the naturalists of Australia, the only continent not invaded by proboscideans. A full list of the names of coöperating authors and investigators is given in Chapter I, pages 13-15, also in the Bibliography at the close of this volume, but I should like to notice here some of the outstanding collaborators and assistants.

My lifelong and honored friend, Andrew F. West of Princeton University, has greatly added to the value of the work by his Latin rendering of the Dedication.

In the United States I am especially indebted to my friend, Erwin H. Barbour of the University of Nebraska, who placed at my service all his materials, his writings and his illustrations. In recent years my research associate, Childs Frick, has rendered most timely service in his explorations, researches and astounding discoveries. European collaboration that has been invaluable was that of Sir Henry Lyons in supporting the Fayûm expedition of the year 1907 with all the resources of the Geological Survey of Egypt. In his assistance on the home stretch of research on this monograph Arthur T. Hopwood has been particularly helpful in the Calcutta and British museums. In both France and Germany I have had the aid of a host of friends.

Craniometry. New methods of measuring the skulls of the proboscideans were initiated in the year 1903 with the aid of William King Gregory in continuation of the new systems of measurement introduced in the researches on the craniology of the Titanotheres. In every subsequent year this most helpful and talented colleague has responded instantly to every call for coöperation and counsel.

Odontography. The grinding teeth are the remains most frequently found and constitute the chief bases of scientific description and classification. The preparation of measurements, calculations and difficult drawings of the evolution of enamel foldings in the stegodontoid and elephantoid branches of the Proboscidea has occupied two years' time in the American Museum and the British Museum (Natural History); this work includes the excellent aid of Edwin H. Colbert of the American Museum staff in the calculation of indices, of William Dixon Lang and William E. Swinton of the British Museum in the new ganometric measurement of the superior and inferior grinding teeth of the proboscideans, of Miss Barbara Hopkins of the British Museum in her admirable drawings of molar tooth sections and of Sir Henry Lyons of the Science Museum in the preparation of diagrams.

Systematic Identification. During the period from 1922 to 1930 Charles Craig Mook assisted in the arrangement of the rapidly incoming collections of fossil mastodonts and elephants. In the year 1930 Doctor Mook was succeeded by Doctor Colbert, who has rendered substantial aid in the more recent identification and measurements of the material. The proboscidean collection now numbers 1235 specimens.

Illustration. Especially outstanding is the superb work of illustration rendered by Lindsey Morris Sterling from the year 1902 to the time of her death in 1931. Beginning with pen drawings of crania in the elephantoid branches, executed in imitation of wood engraving, shown especially in Chapters VI, VIII, X, XIV, XX, Mrs. Sterling with rare intelligence, accuracy and constant enthusiasm prepared the greater number of pen drawings and diagrams for this monograph and is thus entitled to an enduring rank among the leading scientific draughtsmen of the present century. To our deepest regret Mrs. Sterling did not live to see the publication of these volumes in which her work will be preserved for all time.

Reminiscent of the splendid series of illustrations of the extinct reptiles and mammals of North America are the frontispiece and five plates reproduced from the masterly oil, water color and pencil sketches of Charles R. Knight. All these sketches were executed before the habits and characteristics of these proboscideans were so precisely known as at present. In design and artistic conception the Knight restorations are unsurpassed. In

the year 1928 Margret Flinsch, guided by the most recent studies of the author, entered upon the work of restoration of the fossil elephants and mastodonts, after prolonged graphic study of the living elephants. Her work combines a fine sense of accuracy with rare artistic appreciation of the motions and adaptations of these remarkable animals. Beginning with the Mœritheres of the Fayûm she has vigorously and freshly restored, under the author's direction, all the chief types of proboscideans as members of the forty or more genera and twenty-odd subfamilies into which the Order is now divided. A prolonged and very difficult undertaking of the last three years has been the outline restorations of most of the known fossil and living types for phylogenetic charts illustrating the adaptive radiation of the mastodonts and elephants, also the modeling in plaster of the outstanding mastodonts and elephants, aided by the figures of Muybridge.

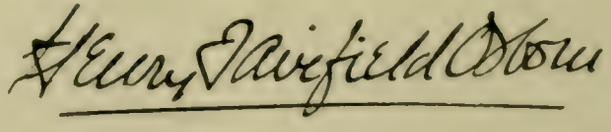
The work of illustration also calls for grateful mention of the following artists: Alastair Brown and Roger Bullard for their pen and pencil sketches; D. F. Levett Bradley for her mapping and lettering; Abram E. Anderson for his fine photographs of skulls and skeletons in the American Museum collection and for his description of the microscopic characters of the enamel of the proboscideans in Volume II; Elwin R. Sanborn of the New York Zoological Society for his photography.

Editing. Beginning in the autumn of the year 1920 and continuing up to the time of publication, Mabel Rice Percy has been the editor-in-chief of these volumes. Rarely fitted by intense appreciation of the possibilities and results of scientific research, as well as by unflagging energy and patience, exceptional memory and rare precision, Miss Percy has rendered imperishable service to the science of palæontology. The taste and beauty of the typographic arrangement, the adjustment of the illustrations, the great labor of examining and correcting succeeding galley and page proofs to make this monograph a consistent and harmonious statement of fact and measurement, are all due to Miss Percy.

In the closing years Ruth Tyler has assisted in the final proofreading and editorial work of the text as a whole and, especially, in the Table of Contents, Bibliography and the Appendix. The introductory pages and Preface have been prepared by Florence Milligan.

Editorial appreciation is also due to Francesca LaMonte and Marcelle Roigneau in the work of translating the citations from the French, Spanish, Italian and Russian languages; to the Staff of the American Museum Library and to Jannette May Lucas for library assistance; to Miss Percy for the extremely difficult assemblage of titles for the Bibliography and to Miss Lucas for assistance in this compilation; under Miss Percy's direction fine work has been done by the American Museum Department of Printing, originally headed by Stephen Klassen and including Miss Gerold and Messrs. Warther, Caggana and Klassen, Jr., and on the home stretch headed by Edward A. Burns with Messrs. Caggana, Haddon and Lewis and Mrs. Price assisting.

I am indebted also to Professor Barbour, Harold J. Cook, Morris Skinner and C. Bertrand Schultz for assistance in field geology; to James L. Clark and Martin Johnson in comparative zoology; to Nels C. Nelson and J. Reid Moir in prehistoric archæology.



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Chapter I

DISCOVERY OF THE LIVING AND EXTINCT PROBOSCIDEANS

1. Principles of revision of generic and specific names.
   - Certain of the names applied to the mammoth and mastodon.
   - Linnæan special creation system (1735–1766).
   - Nomenclatural principles adopted in the present Memoir.
   - Principle of soundly established usage and of common sense.
   - Post–1836–selection of the first soundly established generic or specific name.
   - Determination of the characters, validity, and names of specific types.
2. Revision and adoption of generic names of Proboscidea.
   - Examples of names of prior generic conception and definition, with classic orthography. As adopted by Osborn up to the year 1923.
   - Indeterminate names, collective or section names.
   - Summary of total generic names adopted up to the end of the year 1933.
3. Phylogenetic nomenclature and classification adopted in the present Memoir.
4. Acknowledgments of coöperation and assistance.

The proboscideans and the horses divide the honors of age-long association with man, not only in the historic period but far back into prehistoric times. Whereas the horses entered Eurasia late in Pliocene time and were hunted for food during the closing 100,000-year period, the association of man and the proboscideans appears to have been far more remote, certainly extending back into Upper Pliocene time where we discover more or less conclusive evidence that man hunted the primitive elephants of the period. During the severe environment of the late Palæolithic age, man had become an extremely clever horse hunter, as shown at Solutré in southern France, as well as an extremely clever mammoth hunter, as shown in the "woolly mammoth pit" of Moravia. Whereas many horses were necessary to feed a tribe, a single elephant or mammoth would furnish an entire feast, aside from the priceless materials of bone and ivory to be fashioned for economic and artistic purposes.

From Fable and Myth to Science

From the dawn period of Palæolithic art the mammoth has been looked upon with wonder and curiosity, while the horse has compelled admiration by its beauty and adaptation. This introduces us to a further contrast in the fabulous, mythical, and scientific history of both these remarkable mammals, namely, that the fossil proboscideans of Quaternary age were the first objects in all parts of the world to arouse scientific curiosity, speculation, and finally research. In the Eastern world there sprang up around the mammoth a distinct 'earth-burrowing' myth; in the Western world there was the natural Biblical interpretation that the fossil elephants were a product of the Flood.

But the present volume is devoted entirely to the succession of discoveries in various parts of the world, in fact in all the continents except Australia. These discoveries through the dawn period of scientific research and interpretation have been steadily accumulating. They began in 1695 with the first independent observations on the 'ancient elephant' by Tentzelius (published in 1698). They culminate in the summary (Chap. XXI) of the second volume, in which the full tide of experience and of knowledge brings us to the close of the most complete and remarkable evolutionary history of mammalian descent thus far revealed.

Thus, with only occasional allusion to fabulous and mythologic interpretation which in itself would fill volumes teeming with interest, we set ourselves to the task of progressive scientific interpretation:

First, a period of exploration, discovery, and description which virtually began in 1695 when Tentzelius victoriously argued with the doctors of Gotha that he had actually found a fossil or extinct elephant rather than the remains of a recent elephant as his colleagues hotly contended; continuing (1) with the special creational

influence of Linnæus, Buffon, Blumenbach, and Cuvier, and extending through (2) the intermediate period culminating in the speculations of Hugh Falconer, a contemporary of Darwin; thence (3) into the post-Darwin evolution period, through the bypaths and mazes of erroneous speculation on proboscidean descent, and finally (4) into the illumination of recent time resulting from twenty-seven years of continuous research by the present author in the entire field of proboscidean exploration and discovery.

In brief, the history of the discovery and interpretation of the fossil proboscideans—mastodonts as well as elephants—is coincident and coextensive with the dawn, rise, and development of the science of Vertebrate Palæontology, coupled with our slowly deepening and broadening penetration into the mysteries, principles, and laws of evolution. First, there had to be waged a century-long battle to prove that these more or less petrified specimens were actually fossils belonging to the still unknown world of extinct life; second, another century passed of more or less accurate scientific description and nomenclature, and, finally, a third century of evolutionary interpretation and adaptation of the nomenclature to evolutionary knowledge.

In the various chapters of the present Memoir the history of every great proboscidean type is separately traced from the beginning to the very end of its scientific interpretation, with the fullest justice to the actual facts observed by the authors of each of the four great periods of proboscidean thought. So far as practicable the observations are recorded literally in the language of each author, both as a matter of justice and as a practical matter of the dissemination of the widely scattered and at present inaccessible literature in many different languages. Also, so far as possible, errors of interpretation are omitted, otherwise this volume would embrace a "comedy of errors" and one would lose sight of the main lines of actual fact.

Immense pains have been taken to reproduce every original description in the language of the author, to reproduce every original type figure in facsimile, to retain every original generic name to which the author appears to be entitled by originality of observation, as fully explained below in the section on nomenclature of the present chapter, and finally to give the fullest credit for priority and originality of thought to the great pioneers in prophecy and research, among which are the outstanding names of Tentzelius, Blumenbach, Cuvier, and Falconer.

As to proboscidean bibliography the series of papers bearing on the subject of this Memoir is arranged alphabetically by authors at the close of the present Volume. A clearer idea, however, of the historic development of discovery is shown in the following chronologic arrangement of the writers, greatly renowned, less renowned, or obscure, who have enlightened us on this great subject, from Tentzelius (1698) to the present time.

AUTHORS CHRONOLOGICALLY CLASSIFIED BY THEIR EARLIEST AND LATEST WRITINGS

1. 1698–1836. Tentzelius, Buffon, Linnæus, Blumenbach, Cuvier Period

1602	Avalo y Figueroa, Diego de	1767	Baldassari, Giuseppe	1792	Gmelin, Johann Fridrich
1692	Witsen, Nicolaus	1768	Collinson, Peter	1792	Kerr, Robert
1693	Ray, John	1769	Hunter, William	1795–1829	Geoffroy Saint-Hilaire, Étienne
1696	Ludolf, Hiob	1771–1793	Pennant, Thomas	1795–1836	Cuvier, Georges Léopold Chrétien Frédéric Dagobert
1698	Tentzelius, Wilhelmus Ernestus	1773	Rozier, François		
1706	Ides, Eberhard Ysbrant	1777 [1780]	Pallas, Peter Simon	1799	Corse, John
1715	Réaumur, René Antoine Ferchault de	1778	Buffon, Georges Louis Leclerc de	1802	Lacépède, Bernard Germain Étienne de la Ville
1729	Sloane, Hans	1779–1810	Blumenbach, Johann Friedrich	1803	Artaud, Soulange
1734	Beyschlag, Joannes Fridericus	1782–1786	Merck, Johann Heinrich	1807	Adams, Michael
1734	Seba, Albert	1783	De Fay ——	1807	Link, Heinrich Friedrich
1735–1768	Linnæus, Carolus	1785	Kennedy, Ildephons	1808–1825	Nesti, Filippo
1741	Breyne, John Philip	1785 [1788]	Joubert de, ——	1808–1837	Fischer de Waldheim, Gotthelf
1751–1775	Targioni-Tozzetti, Giovanni	1786	Fortis, Giovanni Battista detto Alberto	1811	Illiger, Carolus
1752[1756]	Guettard, Jean Étienne			1814	Rafinesque-Schmaltz, Constantine Samuel
1764	Daubenton, Louis Jean Marie	1788–1803	Camper, Peter		

1815 Tilesius von Tilnau, Wilhelm Gottlieb
1816 Oken, Lorenz
1816 Smith, William
1818–1820 Desmarest, Anselme Gaëtan
1818 [1821] Sömmerring, Samuel Thomas von
1820 Breislak, Scipione
1820–1823 Borson, Étienne
1820–1823 Schlotheim, Ernst Friedrich von
1820–1824 Krüger, Johann Friedrich
1821–1823 Goldfuss, Georg August
1824–1829 Cuvier, Frédéric
1824–1830 Godman, John D.
1824–1833 Schinz, Heinrich Rudolf
1827 Fitzinger, Leopold Joseph Franz Johann
1827–1853 Eichwald, Eduard von
1828 Clift, William
1828 Croizet, l'Abbé Jean Baptiste
1828 Jobert, Antoine C. G.
1828–1835 Buckland, William
1829 Desnoyers, Jules Pierre François Stanislas

2. 1839–1865. Post-Cuvierian Period Terminating with De Blainville, Laurillard, and Falconer

1821–1869 Gray, John Edward
1824–1831 Cooper, William
1825–1843 Harlan, Richard
1829–1857 Kaup, Johann Jacob
1830–1855 Lyell, Charles
1831 Beechey, F. W.
1831 Brayley, Edward William
1831–1842 DeKay, James E.
1831–1867 Meyer, Hermann von
1832–1841 Hodgson, Bryan Houghton
1833–1869 Brandt, Johan Friedrich
1834 Boué, Ami
1834 Scholl, Johann Baptist
1834–1846 Hays, Isaac
1834–1847 Cautley, Proby Thomas
1836–1848 Klipstein, August von
1836–1875 Lartet, Edouard
1837 Caneto, l'Abbé
1837 Desor, Pierre Jean Édouard
1837 Duméril, André Marie Constant
1837 Geoffroy Saint-Hilaire, Isidore
1837 Jacquemin, Émile
1837 Morren, Charles
1837 Strauss, F. C. J. von
1837–1864 Blainville, Henri Marie Ducrotay de
1837–1889 Burmeister, Hermann
1838 Briggs, C.
1838 Mather, William Williams
1838–1850 Bonaparte, Charles Lucien Jules Laurent
1839–1858 Koch, Albert C.
1839–1872 Foster, J. W.
1840–1842 Horner, William E.
1840–1882 Owen, Richard
1840 Lichtenstein, Martin Heinrich Karl
1841 Gloger, Constantin W. L.
1841 Lund, Peter Wilhelm
1842 D'Orbigny, Alcide
1842 Grant, [R.] E.
1842 Lesson, René Primevère
1842 Nasmyth, Alexander
1842–1843 Couper, J. Hamilton
1845 Jackson, J. B. S.
1845–1867 Falconer, Hugh
1846 Geinitz, Hans Bruno
1846 Gray, Asa
1846 Serres, Pierre Marcel Toussaint de
1846–1855 Giebel, Christoph Gottfried Andreas
1846–1856 Laurillard, Charles Léopold
1846 Hodgson, William B.
1846–1876 Gervais, François Louis Paul
1847 Gay, Claudio
1847 Temminck, Coenraad Jacob
1847–1859 Aymard, Auguste
1847[1850] Jäger, Georg Friedrich
1848 Göppert, Heinrich Robert
1848 Poppelack, F.
1848–1895 Pomel, Auguste
1850 Gibbes, Robert W.
1850–1853 Quenstedt, Friedrich August von
1850–1858 Hoernes, Moriz
1850–1857 Wagner, Andreas
1850–1862 Agassiz, Jean Louis Rodolphe
1850–1864 Costa, Oronzio Gabriele
1851 Sismonda, Eugenio
1852 Girard, Charles
1852 Glocker, Ernst Friedrich von
1852–1858 Hingenau, Otto von
1853 Pictet, François Jules
1853[1854] Lockhart, Charles François
1853–1865 Foetterle, Franz von
1854 Richardson, John
1855 Dorlhac, J.
1855 Reuss, August Emanuel

3. 1859–1894. Darwinian Period Terminating with Leidy, Gaudry, and Cope

1852–1855 Warren, John C.
1853–1896 Leidy, Joseph
1855–1900 Blake, William Phipps
1856 Hauser, Franz
1856–1893 Gaudry, Albert
1858 Rouault, Marie
1858–1861 Jourdan, Claude
1859 Abich, Otto Wilhelm Hermann von
1860 Theobald, William
1861[1858] Gastaldi, Bartolomeo
1861–1862 Schlegel, Hermann
1861–1863 Blake, Charles Carter
1862 Sclater, Philip Lutley
1863 Logan, William E.
1863–1864 Suess, Eduard
1865 Claudius, Matthias
1867 Le Hon, Henri
1867–1868 Busk, George
1867–1868 Murchison, Charles
1867–1891 Gunn, John
1867–1896 Marsh, Othniel Charles
1868–1881 Adams, Andrew Leith
1868–1894 Cope, Edward Drinker
1869–1878 Blanford, William T.
1870 Aradas, Andrea
1870 Fraas, Oscar Friedrich von
1871 Hall, James
1871 Peters, Karl F.
1871–1892 Dall, William Healey
1872 Hayden, Ferdinand Vandeveer
1872–1877 Gill, Theodore
1872–1879 Chantre, Ernest
1872–1879 Lortet, Louis
1873 Dupont, Édouard François
1873 Marschall, Augusto de
1873–1876 Biedermann, W. G. A.
1874 Davies, William
1874 Yates, Lorenzo G.
1875 Bachmann, Isidor
1875 Christy, Henry
1875 Dana, James Dwight
1876 Wallace, Alfred Russel
1876–1883 Major, Charles Immanuel Forsyth
1877 Coues, Elliott
1877 Vacek, Michael
1878–1899 Stefănescu, Gregoriŭ
1878–1902 Ameghino, Florentino
1879 Fuchs, Theodor
1880 Acconci, Luigi
1881 Baretti, Martino
1881 Grewingk, Constantin Caspar Andreas
1881 Hoernes, Rudolf
1881–1883 Brauns, David August
1882–1890 Naumann, Edmund
1882–1890 Nicolucci, Giustiniano
1883 Jentzsch, Carl Alfred
1883 Reiss, Wilhelm
1883 Weinsheimer, Otto
1883–1887 Howorth, Henry H.
1884 Fritsch, K. von
1884 Thomas, Philippe
1884–1890 Martin, Johann Karl Ludwig
1885 Koken, Ernst
1885–1908 Kittl, Ernst Anton Leopold von
1886 Verri, Antonio
1887 Jentink, F. A.
1888 Carles, Enrico de
1888 Moreno, Francisco P.
1888 Rütimeyer, Ludwig
1888–1891 Weithofer, K. Anton
1889 Baur, Georg
1891 Botti, Ulderico
1891 Cantamessa, Filippo
1891 Filhol, Henri

1891 Whitfield, Robert Parr
1893–1911 Hutchinson, Henry Neville
1893 Philippi, R. A.
1893–1896 Portis, Alessandro
1894–1895 Hayes, Seth
1897 Graells, D. Mariano de la Paz
1897–1899 Trouessart, E. L.
1899 Heck, L.
1899 Wagner, George

4. 1900–1933. Phylogenetic Period Terminating with the Publication of the Present Memoir

1876–1916 Lydekker, Richard
1883 Branco [Branca], Wilhelm
1885–1912 Pohlig, Hans
1885–1923 Depéret, Charles
1888–1908 Capellini, Giovanni
1890–1909 Hofmann, Adolf
1890–1922 Newton, Edwin Tulley
1890–1933 Barbour, Erwin Hinckley
1891 Flower, William Henry
1891 Lenk, H.
1891–1901 Zittel, Karl Alfred von
1891–1912 Felix, Johannes
1892 Wortman, Jacob L.
1892–1934 Osborn, Henry Fairfield
1893–1911 Thomas, Michael Rogers Oldfield
1894–1931 Pavlow, Marie
1898–1912 Lambe, Lawrence Morris
1899–1900 Tullberg, Tycho Fredrik Hugo
1899–1920 Boule, Marcellin
1899–1926 Stehlin, Hans Georg
1899–1930 Hay, Oliver Perry
1899–1930 Matthew, William Diller
1900 Matschie, Paul
1900 Sclater, William Lutley
1900–1908 Lucas, Frederick Augustus
1901 Phillips, P. Lee
1901 Wüst, Ewald
1901–1928 Andrews, Charles William
1902 Andrusov, Nikolai Ivanovich
1902 Beadnell, Hugh John Llewellyn
1902 Blake, John Frederick
1902 Herz, Otto
1902 Leney, Frank
1902–1930 Sherborn, Charles Davies
1903 Bourg de Bozas, Robert
1903 Clarke, John Mason
1903 Dawkins, William Boyd
1903 Nordenskiöld, Erland
1903–1930 Sternberg, Charles Hazelius
1903 Stromer, Ernst
1903 Villada, Manuel Maria
1903 Zalensky, Vladimir Vladimirovich
1903–1907 Bate, Dorothea M. A.
1903–1911 Schlosser, Max
1903–1929 Gidley, James Williams
1903–1934 Gregory, William King
1904 Bartolotti, C.
1904 Blanckenhorn, Max
1904 Palmer, Theodore Sherman
1904 Seguenza, Luigi
1904–1908 Dubois, Eugen
1904–1931 De Lorenzo, Giuseppe
1905 Anderson, Netta C.
1905 Maddren, Alfred Geddes
1905 Pompeckj, Joseph Felix
1905 Udden, Johan August
1905–1914 Schuchert, Charles
1905–1926 Pfizenmayer, E. W.
1905–1926 Pilgrim, Henry Guy Ellcock
1905–1928 Hornaday, William Temple
1906 Beck, Richard
1906 Noack, Th.
1906 Tokunaga [Yoshiwara], Shigeyasu
1906 Winge, Herluf
1907 Barbiani, A.
1907 Fraas, Eberhard
1907 Merrill, George Perkins
1907 Sanderson, George P.
1907–1913 Scott, William Berryman
1907–1928 Abel, Othenio
1907–1929 Pontier, G.
1908 Brown, Barnum
1908 Gilmore, Charles Whitney
1908 Wegner, Richard Nikolaus
1908–1910 Bach, Franz
1908–1911 Haug, Émile
1908–1915 Athanasiu, Sava C.
1908–1917 Lull, Richard Swann
1908–1923 Mayet, Lucien
1909 Quackenbush, L. S.
1909–1910 Shimek, Bohumil
1909–1911 Calvin, Samuel
1909–1919 Wadia, D. N.
1909–1927 Freudenberg, Wilhelm
1909–1930 Cook, Harold James
1910 Evans, George Henry
1911 Janensch, Werner
1911 Sierra, Lorenzo
1911 Stremme, Hermann
1911 Terra, Paul de
1911–1922 Schlesinger, Günther
1911–1924 Breuil, Henri
1912 Khomenko, J.
1912–1924 Dietrich, Wolfgang O.
1912–1929 Soergel, Wolfgang
1913 Hilzheimer, Max
1913 Zuffardi, P.
1913–1916 Sellards, Elias Howard
1913–1930 Woodward, Arthur Smith
1914 Buwalda, John P.
1914 Heller, Edmund
1914 Kato, T.
1914 Lomnicki, M.
1914 Newton, Richard Bullen
1914 Niezabitowski, Edward Lubicz
1914 Oswald, Felix
1914 Roosevelt, Theodore
1914 Satō, Denzo
1914 Schouteden, Henri
1914–1932 Reck, Hans
1915 Gez, Juan W.
1915 Sinclair, William J.
1915–1928 Cooper, Clive Forster
1915–1929 Matsumoto, Hikoshichirô
1916 Cotter, G. deP.
1916 Kunz, George Frederick
1916 Merriam, John Campbell
1917–1922 Airaghi, Carlo
1918 Aichel, Otto
1918 Fourtau, René
1918–1927 Stefănescu, Sabba
1919 Bolk, Louis Carles Enrico de
1919 Brives, Abel
1919 Carette, Eduardo
1920 Thevenin, Armand
1920–1928 Joleaud, Léonce
1921 Castellanos, Alfredo
1921 Neuville, Henri
1921–1933 Frick, Childs
1922 Reeds, Chester Albert
1922–1931 Klähn, Hans
1922–1931 Revilliod, Pierre
1922–1932 Haughton, Sidney Henry
1923 Granger, Walter
1923 Hartnagel, Chris Andrew
1923 Petronievics, Branislav
1923 Reyes, Alicia E.
1923 Roman, Frédéric
1924 Capitan, Joseph Louis
1924 Caterini, Francesco
1924 Majer, István
1924 Makiyama, Jirô
1924 Palmer, Rupert William
1924 Peyrony, D.
1924 Stauffer, Clinton R.
1924 Vaughan, Thomas Wayland
1924 Zukowsky, Ludwig
1924–1925 Frade, Fernando
1925 Lang, Herbert
1925 Plate, Ludwig
1925 Sandford, Kenneth Stuart
1925–1928 Furlong, Eustace L.
1925–1929 Eales, Nellie B.
1926 Loomis, Frederic Brewster
1926 Pohle, Hermann
1926 Schmidtgen, O.
1926 Wayland, E. J.
1926–1927 Hopwood, Arthur Tindell
1927 Anderson, Robert Van Vleck
1927 Bather, Francis Arthur
1927 Culver, Harold E.
1927–1929 Cabrera, Ângel
1927–1929 Dart, Raymond A.
1927–1931 D'Erasmo, Geremia
1928 Belĭæva, E.
1928 Broom, Robert
1928 Fabiani, Ramiro
1928 Peterson, Olof August
1928 Romer, Alfred Sherwood
1928 Stock, Chester
1928 Uhle, Max
1928–1929 Borissiak, Alexei Alexievich
1928–1929 Tolmachoff, Innokenty Pavlovich
1928–1931 Spillmann, Franz
1929 Absolon, Karel
1929 Anthony, Raoul Louis Ferdinand
1929–1933 Hayasaka, Ichiro

1929	Heurn, F. C. van	1930	Éhik, Julius	1931	Colbert, Edwin Harris
1929	Prouteaux, M.	1930	Moodie, Roy Lee	1931	Flerov, Constantine C.
1929	Vaufrey, Raymond	1930	Simionescu, Ioan	1931	Teilhard de Chardin, Pierre
1929	Yabe, Hisakatsu	1930	Szalai, Tibor	1931–1932	Sunamoto, Etsujiro
1929–1930	Berckhemer, Fritz	1930–1933	Simpson, George Gaylord	1932	Maarel, Frans Henddrik van der
				1933	Koenigswald, Ralph von

See supplementary Bibliography for 1934 and 1935 at the close of Volume I.

1. PRINCIPLES OF REVISION OF GENERIC AND SPECIFIC NAMES

We should always remember that nomenclature is the *tool* rather than the *master* of palæontologic thought; also that no technical principles should override the work of the early discoverers and naturalists.

In revising the seventeenth to early nineteenth century generic and specific names of Proboscidea, the author has found it impossible either to adopt any consistent rules of nomenclature or to adhere to the International Code of Zoological Nomenclature of the successive editions of 1901 to 1916, which was formulated by zoologists for zoologic practice in which the problems are entirely different from those in palæontologic nomenclature. An *ex post facto* code is difficult in zoology; it is impossible in palæontology until after the time of Cuvier. Zoologic types are complete individual specimens, whereas the early and some of the more recent palæontologic types are often partial, imperfectly known, and still more imperfectly understood. For example, see the succession of names applied to the 'Mammoth,' which will be fully set forth in Chapter XVIII, Volume II, and to the 'Mastodon,' fully set forth in Chapter VI, as well as the generic names listed more fully in chronologic order below.

Certain of the Names Applied to the Mammoth and Mastodon

Insertions by the author are in square brackets

1696 Mammontova Kost Ludloff [Ludolf] (Mammontova, probably derived from the Tatar word *mama* signifying earth, and *kost* signifying ivory tusks). Original citation inaccessible; cited by Fischer de Waldheim ("Oryctographie," III, Fossiles du Gouvern. de Moscou, 1830–1837, p. 111).

"I. Elephant. 1. Le Mammont . . . *Elephas mammonteus.* m. [Fischer, 1830–1837] . . . Je conserve la dénomination la plus ancienne, et je n'écris point *Mammouth* parce que ce nom n'a pris origine que par corruption ou une fausse lecture du mot *Mammònt* [Footnote: 'Мамонтъ en russe; le *Yer* (ъ) terminal a été changé par les anglais en h et le *n* a été pris pour un u. D'ailleurs Ludloff est le premier qui en parle (1696) et appelle ces ossemens Mammontova Kost et justifie ainsi ma dénomination systématique.']."

Cited by Cuvier (Ann. Mus., VIII, 1806, p. 45): "C'est sous le nom de *cornes de mammont, mammontova-kost,* qu'ils désignent les défenses."

1788 Mammonteum Camper (Nova Acta Acad. Sci. Imp. Petropol. Communicanda, II, 1787, p. 251).

[Type: *E. primigenius.*] . . . "os humanum petrifactum, aut fossile, etiamsi Mammonteorum, Elephantorum, . . . Adserere ex eodem principio audeo Mammonteum animal extinctum non modo esse, sed nullam omnino habuisse cum Elephanto similitudinem!"

1806 Mastodonte [= *Mastodon*] Cuvier (Ann. Mus., VIII, 1806, p. 270).

[Type: *M. americanus.*] "Sur le Grand Mastodonte, . . . Animal très-voisin de l'éléphant, mais à mâchelières hérissées de gros tubercules, dont on trouve les os en divers endroits des deux continens, et surtout près des bords de l'Ohio, dans l'Amérique Septentrionale, improprement nommé Mammouth par les Anglais et par les habitans des États-Unis."

1816 Mastodon Oken (Lehrb. Naturges., Dritter Theil, p. 789).

"Mastodon" defined, distinguished from Mammoth and Elephant. Cited: 1. [*?tapiroides*] Montabusard, Saxony. 2. M. of Simorre [*angustidens*]. 3. M. of Chile [*humboldtii*]. 4. M. of Cordilleras [*andium*]. 5. M. of Ohio [*americanus*].

The full and most confusing chronologic sequence of nomenclature of the Mammoth and the Mastodon is set forth in detail in Chapters XVIII, Volume II, and VI, of which the above are examples.

In surveying the above names the question arises whether *Mammonteum* Camper, 1788, may be regarded as a genus with *Elephas primigenius* as the type; also, what is the proper orthography of the word *Mastodonte* G.

Cuvier, 1806, as compared with the word *Loxodonte* F. Cuvier, 1825. If *Loxodonte* is changed to *Loxodonta* as by some authors, why not change *Mastodonte* to *Mastodonta*? Similar difficulties arise in connection with every generic name proposed for the Proboscidea, excepting only the original *Elephas* Linnæus, and even with *Elephas* we are in difficulties, because the Ceylon species, *E. indicus* Linn., 1754, is not admitted by the Code as antedating *E. maximus* Linn., 1758. Cuvier, the founder of vertebrate palæontology and the *first* to clearly conceive and define the real characters of these extinct mammals, was the *last* to adopt the Linnæan binomial terminology. Blumenbach first called the American mastodon *Ohio-Incognitum*, and then *Mammut ohioticum*, because he entirely lacked the comparative anatomical genius of Cuvier.

Linnæan Special Creation System (1735–1766)

The early editions (I to IX inclusive) of the "Systema Naturæ" of Linnæus are not accepted in the International Code of Zoological Nomenclature. It is important to note that Linnæus used the term *Elephas indicus* in 1754 and called the same animal *Elephas maximus* in 1758 ("Systema Naturæ," 1758, p. 33). The Editio Decima, Reformata, of the "Systema Naturæ" by Caroli Linnæi, 1758, is accepted in the International Code as the starting point of modern systematic zoology. In Chapter XX (the Elephantinæ) the specific nomenclature under *Elephas* will be fully discussed.

(Osborn, "From the Greeks to Darwin," 1894, pp. 128–130): Finally the turning-point to modern Zoölogy and Botany was marked by the great work of Linnæus, the *Systema Naturæ*. The binary system of nomenclature therein proposed was a mere tool for the expression of his broad conceptions of the relation of animals and plants to each other. Species were in his mind the units of direct Creation; each species bore the impression of the thought of the Creator, not only in its external form but in its anatomical structure, its faculties, its functions; and the end of classification was to consider all these facts and to arrange animals in a *natural system* according to their greater or less likeness . . . he adopted the aphorism of Leibnitz *natura non facit saltum;* to him every species was exactly intermediate between two others: 'We reckon as many species as issued in pairs from the hands of the Creator.' These were his earlier views in all his writings between 1735 and 1751, in which the sentence *nullæ speciæ novæ* recurs, expressing his idea of the absolute fixity of species from the period of their creation as described in Genesis, the only change being that of the extension in numbers, not of variation in kind. Yet Linnæus was too close an observer to continue to hold this idea of absolute fixity, and in 1762 we find his views had somewhat altered, and this is of particular interest because of the hypothesis which he advanced to explain the origin of new species: 'All the species of one genus constituted at first (that is, at the Creation) one species, *ab initio unam constituerint speciem;* they were subsequently multiplied by hybrid generation, that is, by intercrossing with other species.' He was thus inclined to admit a great increase of species, more or less recent in origin, arising by hybridity, and losing their perfection of type. He elsewhere suggested that degeneration was the result of the influences of climate or environment. In the last and thoroughly revised edition of the *Systema Naturæ*, which appeared in 1766, we no longer find this fundamental proposition of his earlier works, *nullæ speciæ novæ.*

Nomenclatural Principles Adopted in the Present Memoir

In the present revision the author has therefore adopted four principles as applicable up to the year 1836.

1) *Recognition of priority of conception and of definition rather than of technical priority of the name.*
2) *Principle of soundly established usage and of common sense.*
3) *Principle of selection of the first generic or specific name founded on a clearly established character or a clearly designated type.*
4) *Well-known principle of 'elimination' of species which do not belong, and of 'restriction' to species which do belong to the genus.*

The need for such common-sense principles may be illustrated by the case of the names applied to the Mammoth and the Mastodon. The early writers on fossil Proboscidea were without the guidance of modern rules of nomenclature now embodied in the International Code, either as regards: (1) The orthography or etymology of names, or (2) the designation of type specimens, or (3) the consideration of priority of publication; nor did they realize the value of (4) the Linnæan classic orthography, nor (5) the designation of the type locality, nor (6) the geologic level or formation in which types occur.

Consequently to rob Cuvier of his clear conception of grinding tooth structure, which he termed *Mastodonte*, and to substitute the barbaric term *Mammut*, signifying 'earth-burrower,' would be gross injustice to the founder of vertebrate palæontology.

Principle of Soundly Established Usage and of Common Sense

Osborn's second principle of nomenclature accords in general with the successive revisions by G. Cuvier (1799, 1806), by Oken (1816), by G. Cuvier (1817), by Lartet (1836), by Burmeister (1837), by De Blainville (1839–1864), by Gloger (1841), by D'Orbigny (1842), by Falconer (1846, 1857, 1865, 1868), by Laurillard (1846), by Pictet (1853), by Leidy (1869), by Cope (1889), and by Trouessart (1899).

Barbaric and Classic Terms Applied to Elephas primigenius.—The mammoth (*Elephas primigenius* of Eurasia) received a series of christenings beginning in 1696 when Ludolf termed the mammoth "Mammontova Kost," a term cited by Cuvier (1806.1, p. 45), also by Fischer de Waldheim (1830–1837) who insisted that *Mammont* is the proper expression of the Russian vernacular and that *Mammouth* is a corruption. Camper's *Mammonteum* (1788) is cited by Leidy (1869, p. 392). This serves to show that in the nomenclature of the seventeenth and eighteenth centuries the terms Mammont and Mammouth were repeatedly applied both in vernacular and in scientific usage to the animal now known as *Elephas primigenius*. Camper's Latin term *Mammonteum*, by transposition *Mammonteus*, is the first *classic* term applied to the mammoth; a full list of the terms subsequently applied will be cited in Volume II.

Barbaric and Classic Terms Applied to Mastodon americanus.—The corrupt vernacular name *Mammut* Blumenbach (1799), although preoccupied in the vernacular for *Elephas primigenius* and a synonym of *Ohio* Blum. (1797.2), was revived as a genus for the American mastodon by Hay (1902); so far as we know Hay was the first author to recognize Blumenbach's vernacular term *Mammut*, a term not employed in the designation of the type figures by Blumenbach himself. Our greatest American authority on generic names, Palmer (1904), following Hay, has accepted *Mammut* (*op. cit.*, 1904, p. 397); it has also been adopted by Lull (1908). It certainly seems in the interest of palæontology to regard the term *Mammut* as technically preoccupied by *Ohio-Incognitum* Blum. and in historic justice to Cuvier to retain firmly in proboscidean nomenclature the appropriate historic name *Mastodon* Cuvier.

De Blainville's citations (1839–1864, p. 245) of the barbaric and classic generic names applied to *Mastodon americanus* are as follows:

1° Le Grand Mastodonte.

Ohio incognitum, Blumenbach. *Abildungen*, n° 19, 1797.
Elephas Americanus, Pennant.
Mammouth Ohioticum, Blumenbach. Manuel d'Hist. nat.
E. Americanus, molaribus multicuspidibus, lamellis post detritionem quadri-lobatis, G. Cuvier, sur les esp. d'Éléph. viv. et foss. 1798.
Mastodon giganteum, G. Cuvier. Ann. du Mus. VI, p. 270, pl. 49-56, 1805.

'Mastodon' soundly established for Mastodon americanus.—Towards the beginning of the eighteenth century the American mastodon was discovered. In 1771 Pennant named this animal the American Elephant. In 1792 Kerr named this animal *Elephas americanus;* in 1797 Blumenbach (1797.2, Abbildungen, No. 19) first named and figured it as *Ohio-Incognitum;* in 1799 he named it *Mammut ohioticum*, using the preoccupied word *Mammut*, but in 1810 (Abbildungen, No. 19) he again reproduced this figure with the name *Ohio-Incognitum* on the plate. According to Falconer (1846, p. 18) and De Blainville (1839–1864, p. 245) the name *Mastodon giganteum* Cuvier dates 1805; this date is not accepted by Leidy (1869, p. 393) or Palmer (1904, p. 401). In 1806 Cuvier described the animal as "Le Grand Mastodonte," after defining the term in earlier papers (see De Blainville, 1839–1864, p. 245). Cuvier did not at the time adhere to the Linnæan classic orthography in naming his genera,

e.g., Mastodonte (=*Mastodon*). His name was cited, however, by Oken in 1816 as *Mastodon* and by Cuvier himself as *Mastodon* in 1817.

Cuvier's admirable selection of the diagnostic name *Mastodon*, which has since been reprinted millions of times in all the scientific and popular literature, should not be set aside for any form of the barbaric and preoccupied term *Mammut*.

Post–1836–Selection of the First Soundly Established Generic or Specific Name

Osborn's third principle of palæontologic nomenclature is of an entirely different kind; it applies to the rules which should govern us in the *selection* of generic names founded on two or more species which are now known to belong to *one or more different genera*, e.g., the name *Trilophodon* Falconer, *et seq.*

In the chronologic list of Generic Names and Genotypic Species given below, in each instance the following eight rules are observed:

(*1*) *The original orthography is replaced by the classic orthography.*
(*2*) *The earliest known use of the name is cited in the author's orthography.*
(*3*) *The words nomen nudum indicate that the author gave no definition by which the 'species' could be determined; or that the name is a synonym.*
(*4*) *The earliest type figure is cited and where valid and available is reproduced.*
(*5*) *The genotype species are invariably cited in the order given by the original author.*
(*6*) *The geographic locality is cited where given (=Hab.).*
(*7*) *The geologic age or level is cited also (=Type loc.).*
(*8*) *The name or specific determination adopted by the present author is given.*

Important Note.—Few if any of the eight principles of the selection of generic or specific names can with fairness be applied retroactively to the 1698–1836 Cuvierian period, as listed above. A notable illustration of the perils attached to such procedure is afforded by the *first mentioned type specimen* of the species *Elephas primigenius* Blum.; in this classic description Blumenbach first refers to the fossil skeleton described by Tentzelius as unearthed at Burgtonna near Gotha; this skeleton is now positively known to be a specimen of the straight-tusked elephant named *Elephas antiquus* by Falconer in 1847, 1857. The technical type of *Elephas primigenius* Blum. is the specific type of *Elephas antiquus* Falc. Technically, therefore, the species named *primigenius* antedates the species named *antiquus*. Imagine the dislocation of the entire literature of the Proboscidea if the name *antiquus* were substituted for the name *primigenius* on technical grounds covering the modern selection of the *type*, *holotype*, *cotype*, etc.

Determination of the Characters, Validity, and Names of Specific Types

Beginning with the close of the Cuvierian period in the year 1836, we may with greater justice apply the modern principles of palæontologic nomenclature which came into being during the Darwinian period (1859–1894) and which have been gradually clarified and intensified in the phylogenetic period (1900–1933). During the phylogenetic period two important steps have been taken: First, in revising the work of Cope, Leidy, and Marsh, Osborn discovered that the type locality and geologic level were of extreme importance in the study of phyletic series of species; second, Schuchert and others sharpened and clarified the conception of the word *type*, which may have an entirely different significance in palæontology from that conveyed in zoology. Accordingly the modern technical procedure may be summarized under the following eleven rules:

(1) We must *first* determine the geographic locality and where possible the geologic *level* as the starting point of the determination of the *characters of the type*, because both these facts have a very important bearing on generic and specific definition. Experience teaches that the *characters of the original type specimen*, the *geographic locality*, and the *geologic level* on which the specimen was found afford the permanent facts to which all questions of nomenclature must finally be referred in monographic investigation.

(2) The type, where not specifically designated by the original author, is chosen (lectotype) as the first specimen mentioned, the first described, the first figured by the author, consequently great attention has been paid in this Iconography to the selection of the particular specimen or specimens which conform with the author's first description and definition.

(3) Do not confuse the *holotype characters* with other characters based on cotype, paratype, or neotype specimens which the author may have erroneously considered as belonging to the same species as the type. Much of the early systematic work on the Proboscidea was done without discrimination between the *permanent* facts to be derived from the type specimen and the opinions which the original or subsequent authors derived from erroneously associated specimens. Osborn's rule is that specific definition must be based on original types or holotypes only, unless there is absolutely no possibility of doubt that the associated specimens are of the same geologic level and belong to the same species.

Osborn's usage of the terms type (holotype), cotype, paratype, lectotype, and neotype conforms in general with that of Oldfield Thomas (1893), of Cossmann (1904), of Schuchert (1905.1, 1905.2), and of Osborn (1918.473).

(4) TYPE=HOLOTYPE. A particular individual specimen "deliberately selected by the author of a species, or it may be the only example of a species known at the time of original publication. A holotype therefore is always a single individual, but may embrace one or more parts, as the skin, skeleton, or other portions" (Schuchert, 1905.2, p. 10). The holotype must usually be determined from the original description.

(5) COTYPES=COÖRDINATE OR EQUIVALENT TYPES. This term is applicable when the author's type description refers to two or more individuals without selecting or designating one as the holotype, so that all appear to be identified equally, by the original author, with the specific name given. Osborn's custom in such cases is to designate as the type (lectotype) the specimen first mentioned, described, or figured.

(6) PARATYPE=SUBORDINATE OR SUPPLEMENTARY TYPE. Besides the particular individual specimen deliberately selected by the author of a species as the *type*, other specimens mentioned or enumerated in the original description which may supplement the characters of the type may be chosen as *paratypes*. This procedure is especially valuable in palæontology, for the type specimen very seldom consists of a complete individual.

(7) LECTOTYPE=CHOSEN TYPE. "Where the original diagnosis is without illustrations or is accompanied by figures based on two or more specimens, the first subsequent author is at liberty to select from these cotypes a type for the old species, adhering, as far as can be ascertained, to the intention of the original author. Such a type specimen is to be designated as a LECTOTYPE (=a chosen type)." (Schuchert, 1905.2, p 12). The lectotype practice of Osborn in palæontology is either (a) to select the *first* individual specimen named by the original author, because it sometimes happens that the second individual specimen belongs to a distinct species, or (b) to select the specimen to which the specific name or description obviously refers.

(8) NEOTYPE=NEW TYPE. Defined by Schuchert (1905.2, p. 14) as a new "supplementary type selected by an author, on which a species is to rest because of the loss of the original type or where the original material still extant is so poor or fragmentary that from it the characters of the species can not be determined with certainty." Great care must be taken that the neotype comes from the same geologic level as the type.

(9) METATYPE. Defined by Schuchert, after Thomas (Schuchert, 1905.2, p. 14) as "'A specimen received from the original locality [in palæontology, the exact stratum as well] after the description has been published, but determined as belonging to his own species by the original describer himself.' "

(10) TOPOTYPE (Schuchert, 1905.2, p. 14). "In palæontology it is further demanded that the topotype should come not only from the exact locality but also from the identical stratum that furnished the species."

(11) IDEOTYPE (Schuchert, 1905.2, p. 15). "These are the specimens from any place except the original locality, named by an author of a species after publication [e.g., *M. sivalensis*]."

2. REVISION AND ADOPTION OF GENERIC NAMES OF PROBOSCIDEA

We now come to the practical test of the above principles of nomenclature in vertebrate palæontology and find that step by step the application of these principles enables us *to do full justice to the work of the great leaders and discoverers in proboscidean palæontology, such as Cuvier and Falconer, only by setting aside in certain cases the generic and specific names proposed by revisers and reviewers of less authority and of little or no original thought.* The student will observe the following five points:

(1) Great confusion exists in the use of the eighty or more generic names which have been proposed for the Proboscidea.

(2) Much research has previously been devoted to the revision of this nomenclature by De Blainville, Falconer, Leidy, Cope, Trouessart, Ameghino, Palmer, Hay, Matthew, Lull, Schlesinger, and Freudenberg. In the preparation of the present Memoir the author has enjoyed the cordial coöperation of the late Joel A. Allen dean of American mammalogists and highest American authority on zoological nomenclature, of T. S. Palmer author of the invaluable "Index Generum Mammalium," of the late W. D. Matthew who devoted much time and thought to this subject; also of the British Museum authorities, Oldfield Thomas, Charles W. Andrews, and F. A. Bather, as well as C. Davies Sherborn author of the "Index Animalium."

(3) The notes and correspondence relating to this difficult subject are bound and filed in the Osborn Library, including the author's inquiries and replies, under the title: OSBORN'S CORRESPONDENCE, NOMENCLATURE OF THE PROBOSCIDEA, 1921–1935. As in the case of the revision of species, reference is made to these notes and letters as, for example: (Allen, letter, 1921).

(4) The reader will observe between 1758 and 1931 a progressive departure from the Linnæan *conception of a genus.* The generic names first proposed are really *collective or group names*, e.g., *Elephas* equals all elephants, *Mastodon* equals all mastodonts, *Trilophodon* equals all mastodonts with *three* crests in the intermediate molars. Even so recently as 1886 Lydekker embraced all known elephants, recent or fossil, under the single term *Elephas*, and all known mastodonts under the single term *Mastodon;* Freudenberg (1922) has followed this practice.

(5) Recently certain authors who have gone to the opposite extreme have proposed new generic names based on single characters or single stages of evolution.

A. Examples of Names of Prior Generic Conception and Definition, with Classic Orthography. As Adopted by Osborn up to the Year 1923

The generic names proposed or adopted since 1923 are listed below (p. 11)

Elephas Linnæus, 1735–1758, for all the elephants of Indian type. Type *Elephas indicus = maximus.*

Mammonteus Camper, 1788. Type *Elephas primigenius.* This Latinized vernacular name (*Mammonteum* Camper) preoccupies the long series of generic names subsequently applied to the Mammoth, e.g., *Dicyclotherium, Cheirolites, Synodontherium,* and *Polydiskodon.*

Mastodon G. Cuvier, 1806, 1817, for all the zygolophodont mastodonts which are actually related to the genotypic species *M. americanus.*

Loxodonta F. Cuvier, 1825, 1827, for all the elephants of African type. Type *Elephas africanus.*

Deinotherium Kaup, 1829, for all the Deinotheres. Type *Deinotherium giganteum.*

Stegodon Falconer and Cautley, 1846 [1847], 1857, for all pro-elephants which resemble the genotypic species *E. cliftii, E bombifrons, E. ganesa, E. insignis.*

Anancus Aymard, 1855, for all the bunolophodont, brevirostrine mastodonts which are closely related to Aymard's genotypic species *Anancus macroplus = M. arvernensis.*

Trilophodon Falconer, 1846–1857, collective name, restricted to *M. angustidens.*

Tetralophodon Falconer, 1847–1857, collective name, restricted to *M. longirostris.*

Pentalophodon Falconer, 1857–1865, collective name, restricted to *M. sivalensis.*

Rhynchotherium Falconer, 1856–1868, based upon a very distinctive kind of lower jaw from Mexico and including a large number of American forms of similar character. Type *Rhynchotherium tlascalæ.*

Zygolophodon Vacek, 1877, an excellent genus based on the species *M. borsoni, M. turicensis, M. tapiroides, M. pyrenaicus,* all of which are probably interrelated and are certainly distinct from the ancestry of *M. americanus.* Osborn (1926.706) removed *M. turicensis* from *Zygolophodon* making it the type of the genus *Turicius.* He also refers *M. tapiroides* to the genus *Turicius.*

Archidiskodon Pohlig, 1885–1888, founded on the very distinctive specific types *Elephas planifrons* and *E. meridionalis.*

Palæomastodon Andrews, 1901, founded on the very distinctive type *P. beadnelli.*

Mœritherium Andrews, 1901, for all the true Mœritheres. Type *Mœritherium lyonsi.*

Phiomia Andrews and Beadnell, 1902, founded on the very distinctive type *Phiomia serridens.*

B. Indeterminate Names, Collective or Section Names

Unfortunately several of the remaining sixty or more generic names which have been proposed do not rest on such indisputable grounds of *clear conception and definition* as the above. The erroneous or invalid names fall into four categories:

(1) *Indeterminate names*, that is, names defined without a clear conception of generic characters or without a clear designation of the genotypic species, or with an erroneous designation of genotypic species, or other obvious misconceptions. Examples of such names are *Ohio* Blum., 1797, *Mammut* Blum., 1799, *Gomphotherium* Burm., 1837 = *Gamphotherium* Gloger, *Cænobasileus* Cope, 1877, *Hemimastodon* Pilgrim, 1912, *Promastodon* Pohlig, 1912, also *Choerolophodon* Schlesinger, 1917.

(2) *Collective, Section or Group Names.* Names founded on *parallel or convergent dental characters* which arise entirely independently within different genera and different phyla. The earliest outstanding examples of this kind are Falconer's collective section or group names, *Trilophodon, Tetralophodon,* and *Pentalophodon,* e.g.:

Trilophodon Falc., 1846–1857, first used as a Section to include *Mastodon ohioticus, Deinotherium giganteum, M. tapiroides, M. angustidens,* and *M. andium,* species with *three-crested* intermediate molars.

Trilophodon Falc., 1857, subsequently defined as a subgenus, with the genotypic species *M. angustidens.*

Tetralophodon Falc., 1847–1857, first used as a Section to include *Mastodon perimensis, M. sivalensis, M. arvernensis, M. longirostris,* and *M. latidens,* species with *four-crested* intermediate molars.

Tetralophodon Warren, 1852, with the genotypic species: *M. latidens* [= *Stegolophodon*], *M. arvernensis* [= *Anancus*], and *M. sivalensis* [= *Pentalophodon*]. These species obviously belong to several distinct genera or phyla.

Tetralophodon Falc., 1857, subsequently defined as a subgenus, with *M. longirostris* as the genotypic species.

Pentalophodon Falc., 1857–1865, defined to include species with *five-crested* intermediate molars; genotypic species *M. sivalensis.*

(3) *Collective or group names founded upon an erroneous assemblage of species belonging to two or more different genera or phyla.* Examples of names of this kind are in chronologic order as follows:

Mastotherium Fischer, 1814. Genotypic species: *M. megalodon* [= *Mastodon*], *M. leptodon* [= *Trilophodon*], *M. microdon* [= *Turicius*], *M. hyodon* [= *Cordillerion*].

Bunolophodon Vacek, 1877. Genotypic species: *M. arvernensis* [= *Anancus*], *M. pentelicus* [= *Trilophodon* (*Choerolophodon*)], *M. atticus* [= *Turicius*], *M. longirostris* [= *Tetralophodon*], *M. angustidens* [= *Trilophodon*].

Dibelodon Cope, 1884. Genotypic species: *D. shepardi* [= *Rhynchotherium*]. Referred: *D. tropicus* [= *Cordillerion*], *D. humboldtii* [= *Cuvieronius*].

Tetrabelodon, Cope, 1884. Genotypic species: *T. angustidens* [= *Trilophodon*]. Referred: *T. andium* [= *Cordillerion*], *T. productus* = *Serridentinus*].

Polydiskodon Pohlig, 1885–1888. Genotypic species: *Elephas primigenius* [= *Mammonteus*], *E. indicus* [= *Elephas*], *E. namadicus* [= *Palæoloxodon*].

(4) *Obvious synonyms,* as listed below, which are also frequently collective, are readily disposed of, e.g.:

Euelephas Falc., 1857. Genotypic species: *E. indicus* [= *Elephas*], *E. armeniacus* [= *Parelephas*], *?E. hysudricus* [= *Elephas* (*Hypselephas*)].

Several Disputable Names.—From the above analysis it appears that there remain several generic names improperly defined and as to the validity of which there may be decided differences of opinion, namely, *Gamphotherium* Gloger, 1841, *Trilophodon* Falc., 1846–1857, *Tetralophodon* Falc., 1847–1857, *Pentalophodon* Falc., 1857–1865, *Mastotherium* Fisch., 1814, *Bunolophodon* Vacek, 1877, *Dibelodon* Cope, 1884, *Tetrabelodon* Cope, 1884, and *Polydiskodon* Pohlig, 1885–1888.

It is in the usage of such names that the widest differences of opinion have been manifested and that the greatest confusion as to the true *phylogenetic evolution* of the Proboscidea has arisen, for the common reason that all these names were founded on *misconceptions of true relationships*. It is in such a group of names also that it proves impossible to adopt any uniformly consistent principle of revision. Consequently for reasons more fully stated below we have cut the Gordian knot by courtesy to Falconer and have *adopted* three collective generic names, as follows:

Trilophodon Falc., 1846–1857, collective name, restricted to *M. angustidens*.
Tetralophodon Falc., 1847–1857, collective name, restricted to *M. longirostris*.
Pentalophodon Falc., 1857-1865, collective name, restricted to *M. sivalensis*.

We have *eliminated* five other collective names, because they are *synonyms* of collective names previously proposed, namely:

Mastotherium Fischer, 1814, collective name, also a synonym of *Mastodon*, etc.
Bunolophodon Vacek, 1877, collective name, also a synonym of *Anancus*, of *Tetralophodon*, of *Trilophodon*.
Dibelodon Cope, 1884, collective name, also a synonym (in part) of *Mastotherium* and of *Tetrabelodon*.
Tetrabelodon Cope, 1884, collective name, also a synonym of *Trilophodon* and of *Dibelodon*.
Polydiskodon Pohlig, 1885–1888, collective name, also a synonym of *Mammonteus*, of *Elephas*, and of *Loxodonta*.

Summary of Total Generic Names Adopted up to the End of the Year 1933

The sixteen generic names adopted up to the year 1923 as representing distinct and separate phyla, namely, *Elephas*, *Mammonteus*, *Mastodon*, *Loxodonta*, *Deinotherium*, *Stegodon*, *Anancus*, *Trilophodon*, *Tetralophodon*, *Pentalophodon*, *Rhynchotherium*, *Zygolophodon*, *Archidiskodon*, *Palæomastodon*, *Mœritherium*, and *Phiomia*, are now amplified by the adoption of *Stegomastodon*, *Eubelodon*, *Stegolophodon*, *Miomastodon*, *Cuvieronius*, *Serridentinus*, *Ocalientinus*, *Serbelodon*, *Parelephas*, *Pliomastodon*, *Turicius*, *Palæoloxodon*, *Cordillerion*, *Amebelodon*, *Platybelodon*, *Synconolophus*, *Notiomastodon*, *Hesperoloxodon*, *Platelephas*, (?) *Hypselephas*, *Trobelodon*, *Blickotherium*, and *Aybelodon*.

The addition of twenty-three generic names to the sixteen first listed, making thirty-nine[1] in all, does not signify the discovery of thirty-nine[1] distinct phyla or branches, because certain of these genera represent geologic sections in certain branches; for example, it is probable that *Miomastodon*, *Pliomastodon*, and *Mastodon* were actually successive genera; similarly that *Phiomia* branched into *Amebelodon*.

Eliminating such succession of genera, we have thus far discovered no less than twenty-six great phyla in which our knowledge includes one or more sections conveniently designated as Genera.

Stegomastodon Pohlig, 1912, founded on the *Mastodon mirificus* of Leidy
Eubelodon Barbour, 1914. Type *Eubelodon morrilli*, a single individual from Devil's Gulch, Nebraska.
Stegolophodon Schlesinger, 1917, founded on the distinctive type of *Mastodon latidens* Clift.
Miomastodon Osborn, 1922. Type *Mastodon merriami*, a Middle Miocene mastodont intermediate in character between *Palæomastodon* and *Mastodon*.
Cuvieronius Osborn, 1923, based upon the species *Mastodon humboldtii* Cuvier, characterized by double trefoils and tusks without enamel band.
Serridentinus Osborn, 1923. Genotypic species: *Mastodon productus* Cope, *M. serridens* Cope, *M. floridanus* Leidy, *M. obscurus* Leidy, and *Serridentinus* [= *Trilophodon*] *simplicidens* Osborn.

[1]Forty-one by the addition of *Torynobelodon* and *Gnathabelodon*.

Parelephas Osborn, 1924. Upper Pliocene to Upper Pleistocene genus based on the species *Elephas jeffersonii* Osborn, of Indiana.
Pliomastodon Osborn, 1926, a Pliocene stage based on the species first described by Osborn as *Mastodon matthewi*, subsequently as *Pliomastodon matthewi*.
Palæoloxodon Matsumoto, 1924, founded on *Elephas namadicus naumanni* Makiyama.
Turicius Osborn, 1926, based on *Mastodon turicensis* Schinz, one of the genotypes of *Zygolophodon* Vacek, 1877.
Cordillerion Osborn, 1926. Type *Mastodon andium* Cuvier, characterized by single trefoils and spirally twisted tusks with enamel band.
Amebelodon Barbour, 1927. Type *Amebelodon fricki*, distinguished especially by its shovel-shaped tusks.
Platybelodon Borissiak, 1928. Type *Platybelodon danovi*, distinguished especially by its flat tusks.
Synconolophus Osborn, 1929. Type *Synconolophus dhokpathanensis*, a very progressive species of this phylum from the Middle Pliocene of India.
Notiomastodon Cabrera, 1929, founded on the distinctive type *Notiomastodon ornatus*.
Hesperoloxodon[1] Osborn, 1931, provisionally proposed, with *Palæoloxodon antiquus italicus* as the type, representing a phylum quite distinct from that of '*Elephas namadicus*' of the Siwaliks.
Blickotherium Frick, 1933. Type *Blickotherium blicki* Frick. A Rhynchorostrine with peculiarly formed symphysis and laterally compressed, enamel-banded incisors.
Aybelodon Frick, 1933. Type *Aybelodon hondurensis* Frick. A Rhynchorostrine with slender jaws, upcurved rostrum, and enamelless tusks.
Trobelodon Frick, 1933. Type *Trobelodon taoensis* Frick. Of Serridentine relationship.
Ocalientinus Frick, 1933. Type *Ocalientinus ojocaliensis* Frick. Serridentine grinders, abbreviate cranium, and elongate, troughlike rostrum.
Serbelodon Frick, 1933. Type *Serbelodonbarbourensis* Frick. Short, broad symphysis and laterally flattened incisors.
Platelephas gen. nov.[1] Type *Elephas platycephalus* Osborn, having a relatively elongate, dolichocephalic, and platycephalic cranium.
Hypselephas gen. nov.[1] Genotypic species: *Elephas hysudricus* Falconer, 1845, 1846, and *Elephas platycephalus angustidens* Osborn, 1929.

3. PHYLOGENETIC NOMENCLATURE AND CLASSIFICATION ADOPTED IN THE PRESENT MEMOIR

Modern terminology and classification express the discovery of lines of descent. As clearly shown in Chapter II of the present Memoir, the Osborn phylogenetic system (1892–1931) adapts the Linnæan 'special creation' nomenclature to the Darwinian 'divergent-evolution' principle of descent. As set forth in a long series of writings on this subject, beginning with Osborn, 1892.67, an essential outcome of Darwinism is the substitution of a nomenclature conformable to the divergent branching or polyphyletic adaptations of the Proboscidea to diverse habitats and different feeding habits.

Evolutionary Stage Theory. In the 14th edition (1929) of the Encyclopaedia Britannica the articles Proboscidea, Elephant, Mammoth, and Mastodon summarize the general knowledge of these animals as prevailing in the decades previous to the year 1929. These divide the Proboscidea into the following nine stages:

1st Stage. *Mœritherium*, Upper Eocene of Egypt. Very primitive.
2d Stage. *Palæomastodon*, Lower Oligocene of Egypt. Great advance on *Mœritherium*.
3d Stage. *Tetrabelodon angustidens*, Lower Middle Miocene of Europe. Advance on *Palæomastodon*.
4th Stage. *Tetrabelodon longirostris*, Pliocene of Europe. In external appearance entirely elephantine.
5th Stage. *Mastodon*, Pleistocene. Terminal stage of the mastodonts.
6th Stage. *Deinotherium*, Mio-Pliocene of Eurasia. Side branch.
7th Stage. *Stegodon*, Pliocene of India. Transitional to the elephants.
8th Stage. *Elephas antiquus* of Eurasia and other Plio-Pleistocene species.
9th Stage. *Elephas maximus*, *E. africanus*, of India and Africa.

The arrangement of the Proboscidea in these nine stages accords with the outworn belief among zoologists that one or more of these stages represents a successive or ascending order; for example, that *Mœritherium* gives rise to *Palæomastodon*, as, in turn, *Mastodon* passes into *Stegodon* and then into *Elephas*. This prevailing belief is entirely erroneous; it is a vestige of *monophyletic* theories of animal descent which in the past have been largely due to the breaks and gaps in our palæontologic collections. Now that these gaps are in a great measure filled by discovery and these animals intensively studied, the older monophyletic theories prove to be illusory; they

[1]Description in forthcoming Volume II (The Elephantoidea).

are wholly superseded and replaced by *polyphyletic* systems in which each of the generic phyla, even of the Oligocene, passes back into fundamental divisions that occurred during Eocene times. It is proven that the divergence or branching of the Proboscidea, like that of all other ungulates, was well advanced in the Eocene.

In brief, it becomes necessary to replace the old *evolutionary stage theory* by the new *polyphyletic adaptive radiation theory* of Osborn.

Polyphyletic Adaptive Radiation Theory.—Each of the successive chapters of this Memoir (Chap. II, "Origin and Classification of the Proboscidea," to Chap. XX, "The Subfamily Elephantinæ") contains a full exposition not only of the principles of adaptive radiation but of the necessary modification of the nomenclature by polyphyletic discovery. Finally in Chapter XXI ("Affinities, Migrations, and Phylogeny") the whole subject of the adaptive evolution of the Proboscidea along polyphyletic lines is fully set forth.

Each of the forty-one genera finally established in the present Memoir represents a clearly distinct stage of descent; for example, it has very recently been determined that the line of descent terminating in the *'Elephas namadicus'* of India is quite distinct from the line of descent terminating in the *'Elephas antiquus italicus'* of western Europe. It follows that, not only as a matter of convenience but as an expression of truth, different generic names must be applied to these two lines of descent and to their African relatives, namely:

Elephas antiquus line of descent=*Hesperoloxodon* Osborn, 1931.

Elephas namadicus line of descent=*Palæoloxodon* Matsumoto, 1924.

Elephas africanus line of descent=*Loxodonta* F. Cuvier, 1825, 1827.

Thus our modern phylogenetic knowledge completely revolutionizes all the older taxonomic systems and theories.

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As recited in the Preface and more fully in Chapter II, the preparation of this Memoir began in the year 1907 with the author's expedition to the Fayûm of northern Egypt, accompanied by Walter Granger as head of the mammalian palæontology staff of the American Museum. This eventful journey verified and amplified the remarkable discoveries of Hugh J. L. Beadnell and Charles W. Andrews, and determined the author to give the Proboscidea monographic treatment similar to that of the Titanotheres.

At the time there was little conception of the difficulties of the undertaking. First entered upon in the midst of the concluding phases of research on the Titanotheres—the Titanothere Monograph having been sent to press in 1920—intensive work on the Proboscidea Memoir has continued with periods of interruption for fourteen years—altogether twenty-seven years.

It soon became obvious that the coöperation of practically all the mammalian palæontologists of the world was essential to a comprehensive and thorough treatment of the subject. It would be impossible to express to each of these collaborators the full measure of the author's appreciation; it is, moreover, difficult to give a complete list of those who have helped in many ways.

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The outstanding names of the collaborators in the Volume include several great and highly esteemed colleagues who have fallen by the way, such as Charles Depéret of Lyons, William D. Matthew, Joel A. Allen, Frederic A. Lucas and Carl E. Akeley of the American Museum, James W. Gidley of the U. S. National Museum, Paul Matschie of the Natural History Museum of Berlin, John Mason Clarke of the New York State Museum, and finally, but not least, Charles W. Andrews of the British Museum. These names, indicated on the Honor Roll by a star, are included in the above list of those who have coöperated more or less extensively with the author in the present work.

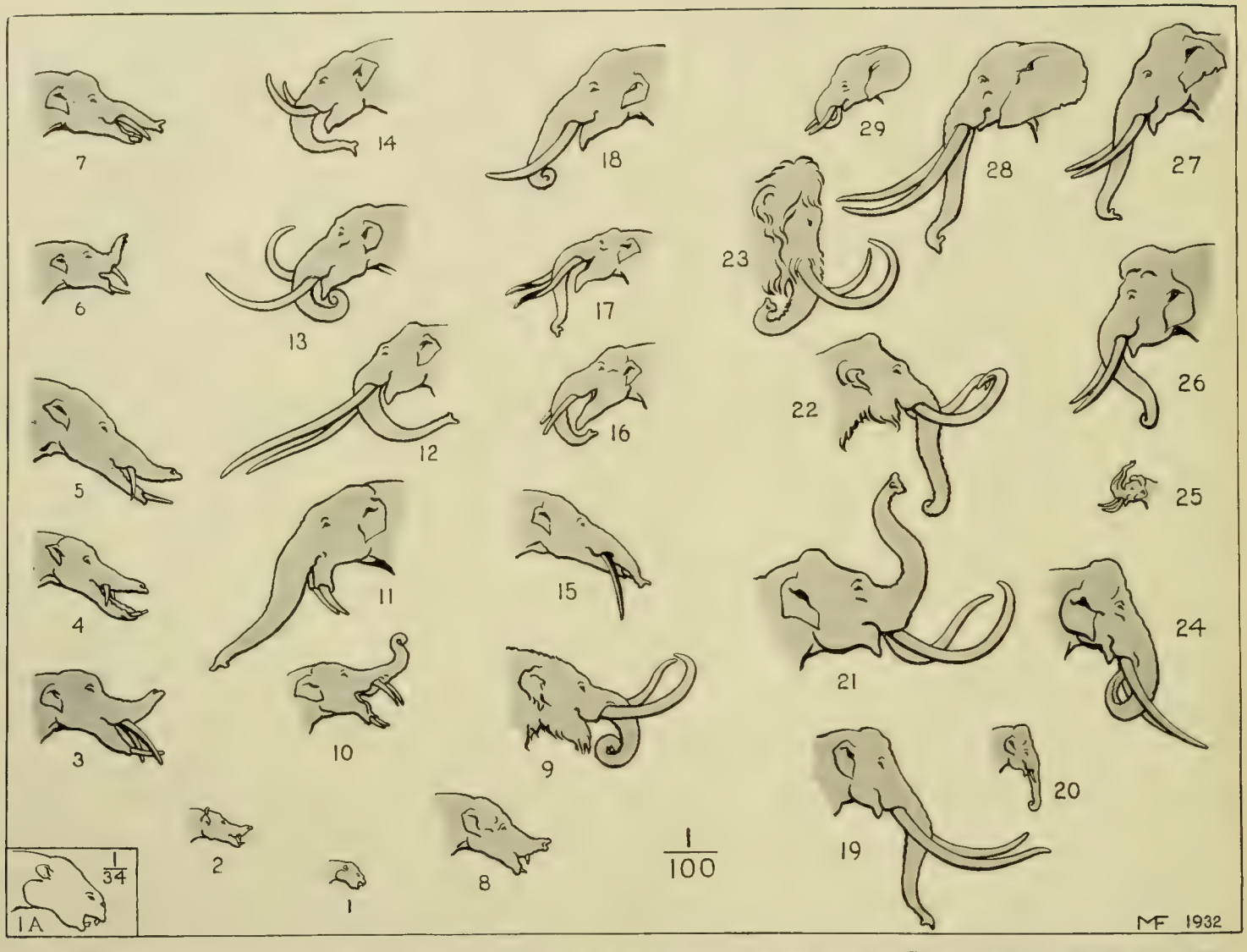


Fig. 1. Heads of twenty-nine Types of Proboscideans belonging to seventeen of the nineteen Subfamilies as determined by the present Author. Restorations by Margret Flinsch (1932), under the direction of Henry Fairfield Osborn

All figures one-hundredth natural size, excepting 1A which is one thirty-fourth natural size.

1, 1A *Mœritherium lyonsi* Andrews.
2 *Phiomia osborni* Matsumoto.
3 *Trilophodon angustidens* Cuvier.
4 *Platybelodon grangeri* Osborn.
5 *Amebelodon fricki* Barbour.
6 *Serridentinus serridens* Cope.
7 *Tetralophodon punjabiensis* Lydekker.
8 *Palæomastodon beadnelli* Andrews.
9 *Mastodon americanus* Kerr.
10 *Rhynchotherium tlascalæ* Osborn.
11 *Deinotherium gigantissimum* Stefănescu.
12 *Anancus arvernensis* Croizet and Jobert.
13 *Synconolophus dhokpathanensis* Osborn.
14 *Stegomastodon arizonæ* Gidley.
15 *Notiomastodon argentinus* Ameghino.
16 *Eubelodon morrilli* Barbour.
17 *Cordillerion andium* Cuvier.
18 *Cuvieronius superbus* Ameghino.
19 *Stegodon ganesa* Falconer.
20 *Stegodon trigonocephalus* Martin.
21 *Archidiskodon imperator* Leidy.
22 *Parelephas jeffersonii* Osborn.
23 *Mammonteus primigenius* Blumenbach.
24 *Hesperoloxodon antiquus italicus* Osborn.
25 *Palæoloxodon falconeri* Leith Adams.
26 *Palæoloxodon namadicus* Falconer.
27 *Elephas indicus* Linnæus.
28 *Loxodonta africana* Blumenbach.
29 *Loxodonta africana pumilio* Noack.

Chapter II

ORIGIN AND CLASSIFICATION OF THE PROBOSCIDEA BEGINNING WITH MŒRITHERIUM, PALÆOMASTODON, AND PHIOMIA

I. Linnæan Zoological Classification and Osborn's Phylogenetic Classification of the Proboscidea.
1. Principles of the Osborn Phylogenetic Classification.
2. Origin of the Proboscidea.
3. The primary stocks established by primary choice of food in different habitats.
4. Ordinal, subordinal-superfamily, family, subfamily-phyletic, generic-phyletic characters employed in the phylogenetic classification of the Proboscidea.
5. Harmony of Linnæan and phylogenetic classification expressing our knowledge up to the close of the year 1933.

II. Osborn's Theory (1900) as to the African Origin or Center of Adaptive Radiation of the Proboscidea.
1. Andrews confirms the African origin of the Proboscidea, Sirenia, and Hyracoidea.
2. American Museum Fayûm Expedition of 1907. Interpretation and discovery bearing on the phylogeny of the Fayûm Proboscidea.
3. Relations of *Mœritherium*, *Palæomastodon*, and *Phiomia* to each other and to other mammals.
4. Matsumoto's complete separation of *Mœritherium*, *Palæomastodon*, and *Phiomia*.
5. Africa demonstrated as the homeland of the three families Mœritheriidæ, Mastodontidæ, and Bunomastodontidæ.

III. Phylogenetic Relations and Classification of Mœritherium, Palæomastodon, and Phiomia.
1. Principle of adaptive radiation expressed in the phylogenetic classification of the Fayûm Proboscidea.
2. Amphibious habits of *Mœritherium*.
3. Lowland habits of *Phiomia*, ancestor of the Amebelodontinæ.
4. Forest-loving habits of *Palæomastodon*, not ancestral to *Mastodon*.

IV. Revision and Synopsis of Genera, Species, and Types of the Fayûm Proboscideans in the Order of Their Original Description.
1. *Palæomastodon beadnelli* Andrews, 1901.
2. *Mœritherium lyonsi* Andrews, 1901.
3. *Phiomia serridens* Andrews and Beadnell, 1902
4. *Mœritherium gracile* Andrews, 1902.
5. *Mœritherium trigodon* Andrews, 1904.
6. *Phiomia minor* Andrews, 1904.
7. *Palæomastodon parvus* Andrews, 1905.
8. *Phiomia wintoni* Andrews, 1905.
9. *Phiomia barroisi* Pontier, 1907.
10. *Mœritherium andrewsi* Schlosser, 1911.
11. *Palæomastodon intermedius* Matsumoto, 1922
12. *Phiomia osborni* Matsumoto, 1922.
13. *Mœritherium ancestrale* Petronievics, 1923.

INTRODUCTION

Classification.—The *classification* of the Proboscidea progresses with our ever increasing knowledge of *origins*, *adaptive radiations*, and *phyletic successions*. Consequently classification is progressively modified by discovery and research. The classification in the present Memoir attempts to set forth our general knowledge of the evolution of the Proboscidea up to the end of the year 1933; the nomenclature, that is, lists of genera, species, etc., chiefly terminates at the close of the year 1933, because it is impossible to include all the new specific and generic lists of 1934 up to the moment of going to press. The classification of 1935 concludes the present Volume.

Our rules of nomenclature will be a shock to many zoologists, especially to those who carry the principle of priority to the point of adopting misspelled, misapplied, and practically unpublished names. After the most honest and painstaking endeavor, we have found it impracticable to apply uniformly all the principles established in zoology to nomenclature in palæontology. The fundamental reason is that the imperfect data of many original

descriptions in palæontology are in wide contrast to the usually perfect data of zoology. The art of nomenclature is entirely different in these two branches. Consequently the rules of nomenclature framed by zoologists will inevitably be different in certain respects from those which can be adopted by palæontologists. Certain of the reasons for this statement will become clear in the following sections.

Origin.—Our present knowledge of the origin of the Proboscidea begins with the wonderfully varied and interesting forms discovered in the Fayûm region of North Africa in 1901 and successively examined by Andrews, Schlosser, Matsumoto, Petronievics, and Osborn between 1901 and 1923. In the systematic revision all of these Fayûm animals will have to be considered together; they are therefore treated in chronological order of description in the present chapter, although it is now known that they belong to at least *three distinct phyla.* After being thus separated phyletically, they are again treated in succeeding chapters in their *true phylogenetic order,* namely:

Palæomastodon, forest loving, the possible phyletic ancestor of the Mastodontidæ.
Phiomia, shore loving, certainly the collective ancestor of the shovel-tusker *Amebelodon.*
Mœritherium, water loving, standing and ending in a phylum by itself.

Flood-plain Scene of the Ancient River Nile, North Africa, in Lower Oligocene Time
Restoration by Margret Flinsch (1932), under the Direction of Henry Fairfield Osborn

Fig. 2. Theoretic restoration of *Palæomastodon beadnelli* (upper left), *Phiomia osborni* (upper right), and *Mœritherium andrewsi* (upper center), all one-fiftieth natural size. *Mœritherium lyonsi* in foreground one-thirtieth natural size.

I. LINNÆAN ZOOLOGICAL CLASSIFICATION AND OSBORN'S PHYLOGENETIC CLASSIFICATION OF THE PROBOSCIDEA

Linnæan Classification (Linnæus, 1735–1766) aimed to define the apparent relationships and affinities of *existing animals* as they were created and spread contemporaneously on the present surface of the earth, and as revealed by the comparative anatomy and zoology of existing animals. The "Systema Naturæ" of Linnæus is zoological and creational.

Phylogenetic Classification (Osborn, 1892–1933) aims to distinguish *ties of blood and descent among ancestral as well as existing mammals;* it also aims to adapt and modify the Linnæan classification to the discoveries of palæontology, namely, to include animals belonging to *phyla* or ancestral lines and to connect them with existing animals. It expresses the nearness or the remoteness of phyla of all degrees of magnitude, namely, phyla of species, genera, subfamilies, families, orders. The term Phylum has a larger taxonomic significance, e.g., Phylum Chordata = animals with a notochord.

The word *phylogenetic* signifies the origin or genesis of lines of descent of ancestral animals unknown to Linnæus. The word *phylum* is derived from the Greek (cf. Liddell and Scott, "A Greek-English Lexicon," 1883, pp. 1698, 1703): "φῡλή, ἡ (φύω) properly, like φῦλον, *a set of men naturally distinct;* . . . In usage φυλή corresponded to the Roman *tribus*, and signified I. *a body* of men *united:* 1. *by supposed ties of blood and descent, a clan* or *sept*, such as those among the Dorians, . . . or 2. *by local habitation*," (p. 1698). "φύω, . . . A. trans., . . . *to bring forth, produce, put forth,* φύλλα. . . . B. Pass., . . . *to grow, wax, spring up* or *forth, arise, come into being*," (p. 1703).

1. PRINCIPLES OF THE OSBORN PHYLOGENETIC CLASSIFICATION

In 1891, Osborn began to apply a system of phylogenetic classification to the order Perissodactyla (1892.67) and developed it in subsequent years especially in treating the family Rhinocerotidæ (1900.192) and finally the superfamily Titanotherioidea (1929). The purpose of this classification of the Proboscidea is to express our present knowledge of the more or less profound gaps between the greater and the lesser branches. Most of the older classifications were based on the idea that there were but two genera, *Elephas* and *Mastodon*. Cope (1889.2) divided the Proboscidea into many genera but did not propose a phylogenetic classification. Gaudry (1862–1878), Leith Adams (1877–1881), Pohlig (1888–1909), Weithofer (1890), Pilgrim (1905–1926), Soergel (1912–1921), Lull (1908), Matthew (1915), Schlesinger (1917–1922), Boule (1920), and Freudenberg (1922) have successively discussed and enriched our knowledge of the phylogeny of the Proboscidea but have not expressed this knowledge in classification.

Osborn (1907) began his observations upon the Proboscidea and his survey of the literature covering the years 1735 to 1934; in 1918 (1918.468), he began the special series of studies on *classification as expressive of the phylogeny of the Proboscidea* which has culminated in the present Memoir.

Osborn, 1934: The advantage of a phylogenetic classification of the Proboscidea is that the superfamilies or suborders expressed with the terminal -oidea indicate the four[1] larger branches into which the Proboscidea are now known to be divided; the family subdivisions corresponding with the terminal -idæ express the five[1] known subdivisions, leaving space for the unknown families; the third system of branching, expressed with the subfamily terminal -inæ, indicates the seventeen[1] subfamilies, three of which are now positively known to be as ancient as Lower

[1](Osborn, 1935) Five larger branches (-oidea), eight families (-idæ), and twenty subfamilies (inæ) are now known. See Appendix of the present Volume.

Oligocene time; beneath these branches are the forty-one or more generic phyla, each of which embraces a very long line of *specific* and *subspecific* descent. This phylogeny of 1933–1934 is shown in figure 8.

The chief difficulty with a phylogenetic classification of the Proboscidea, as of the Perissodactyla or other orders of mammals, is a technical one, namely, to harmonize it, on the one hand, with the Linnæan "special creation" system of nomenclature, and, on the other, with the prevailing usage of family, subfamily, and generic nomenclature in mammalian zoology, which systems are alike based on affinities displayed between the existing terminal twigs of the branches and subbranches rather than on the affinities of the *phylogenetic lines* which connect the existing twigs with their geologically remote and fundamental ancestral branches. By Linnæan and post-Linnæan systematists upwards of fifty[1] generic names have been applied to the mastodonts and elephants, but there is no uniformity in the application of these generic names among palæontologists or zoologists, nor has any other principle of revision or of arrangement been worked out by which one may at least *begin* an advance toward a permanent system of nomenclature of this highly important and interesting group, except the present phylogenetic system.

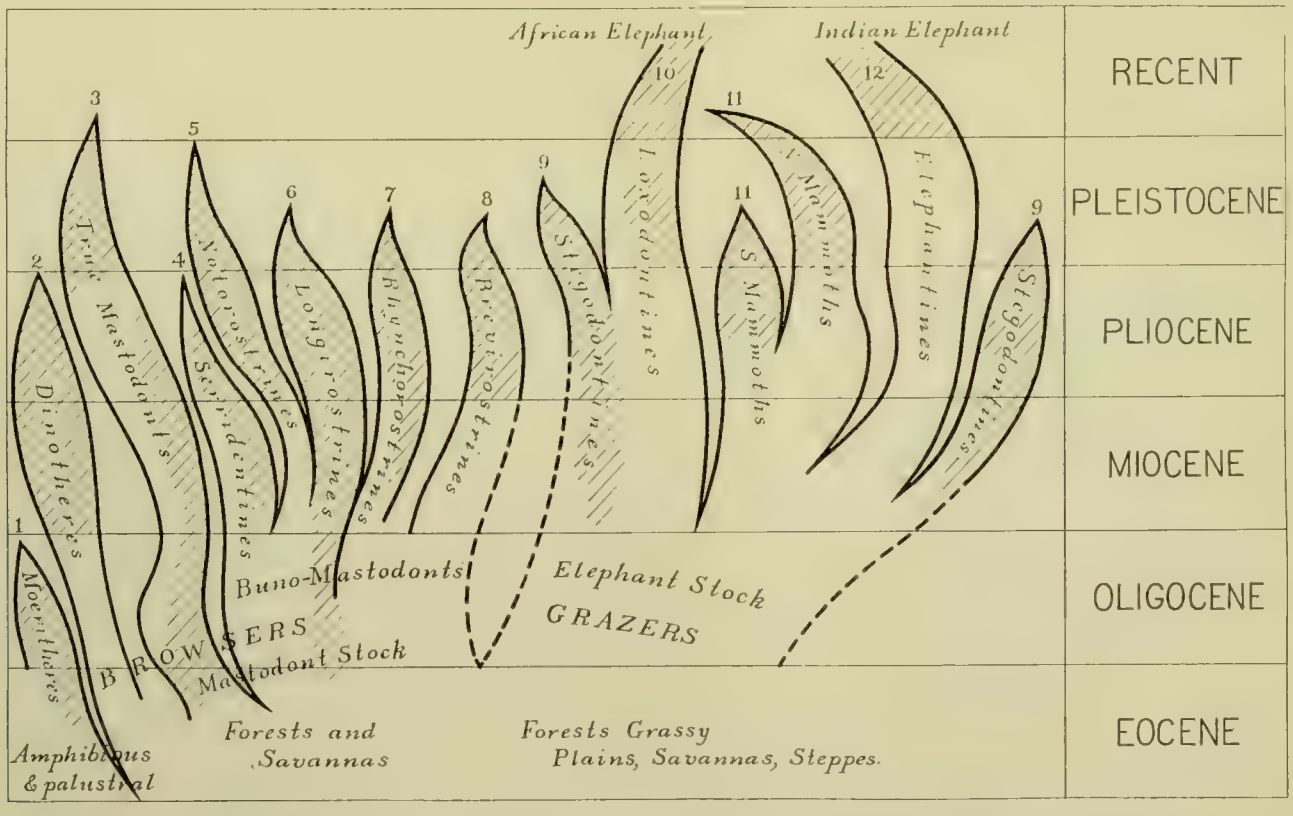


Fig. 3. Diagram showing Osborn's theory so far as developed up to June, 1921, as to the Adaptive Radiation of the Proboscidea. After Osborn, 1921.532, p. 233, Fig. 1. Compare diagrams of 1925, 1933–1934, and 1935 below.

Apart from its theoretic value there is an honest difference of opinion about the practicability of a phylogenetic system of classification; some of the leading palæontologists, like W. D. Matthew (letters, February, 1918), do not think it is practicable; other colleagues, like W. K. Gregory (letters, February, 1918), do not consider that the subfamily division (-INÆ) can be properly applied to vertical lines of succession. But to Osborn there does not

[1]This estimate was made in 1923; at the close of the year 1933 upwards of eighty genera had been listed by the present author (see Chap. I, p. 9); also for complete list of genera and species, see Volume II.

appear to be any alternative between the continuation of the hopeless confusion which at present prevails in the nomenclature and arrangement of the Proboscidea and the absolute illumination and clarity which are thrown upon the whole subject by the adoption of the phylogenetic classification.

In our present phylogenetic revision the only possible way of straightening out the *genera* is by first straightening out the *phyla* in which they belong. The same is true in regard to the *species;* the species can be understood only in their phyletic relations. Consequently the prelude to our phylogenetic classification has been the prolonged and very difficult research on the actual characters of the types of genera and of species, upon which the author has been closely engaged for the last sixteen years (1918–1934). During this period the author has learned a great deal about the phylogeny of the Proboscidea from other observers and from his own observations, but many phyla still remain obscure and imperfectly known; much is to be added to our knowledge by the more intensive study of materials already in hand and of the very rich materials still to be discovered, especially in central and northern Asia and northern Africa.

Thus a phylogenetic classification is never final; it is always progressive and adaptive to future discovery. Osborn's classifications of 1921 to 1926 appear to be marked advances upon that of 1918; doubtless it will be progressively and perhaps largely modified through future discovery. This is as it should be, because *nomenclature and classification are the tools of thought*, not the masters of thought as some systematists would have it. Other phylogenies are those of 1925 (Fig. 7) and of 1933-1934 (Fig. 8) bringing us up to 1935, see the Appendix of this Volume.

With a reasonable rather than a strained regard for priority, *nomenclature and classification are the plastic vehicles of expression of the actual knowledge of relationships and phylogeny.* A reasonable recognition of all the great ideas of the past combined with provision for the ideas and the discoveries of the present and of the future —these are the watchwords of Phylogenetic Classification.

2. ORIGIN OF THE PROBOSCIDEA

As remarked above, phylogenetic classification depends progressively upon the discovery of origins, of adaptive radiations, and of phyletic successions.

The discovery of *primary stocks* by palæontologists naturally comes last, long after the zoologists have discovered recent or existing species. Thus the existing elephants have been known by man for thousands of years, but the three primary stocks from which they were derived were not discovered until 1901. These primary stocks give us the roots and greater branches of our system; the lesser branches have afforded the progressive knowledge of adaptive radiation and the still more elusive knowledge of direct phyletic succession.

The distinguishing feature of this Memoir, which we trust will be of permanent value, is the separation of many direct phyletic lines of descent from each other and the recognition of many mastodonts and elephants which are very much alike in certain characters, but which are still more unlike in other characters and cannot possibly be descended one from the other.

3. THE PRIMARY STOCKS ESTABLISHED BY PRIMARY CHOICE OF FOOD IN DIFFERENT HABITATS

If we watch ungulates while feeding, we observe that they are very fastidious in the choice of food. Consequently the beginning of adaptive radiation lies in the choice of food and of feeding habitat. There is a great deal of truth in Lamarck's idea that the wish precedes the organ. Coadaptation and compensation follow the primary choice of food.

The origin and evolution of the three kinds of Fayûm proboscideans as described below (p. 34 to p. 50) are only part of the evidence for a long continued antecedent adaptive radiation process beginning in the Upper Cretaceous and extending throughout Eocene time, by which the Proboscidea, like other hoofed animals, were broken up into several great primary stocks, namely:

An amphibious stock, adapted to rivers and swamps, of limited powers of migration. Represented only by the imperfectly known *Mœritherium* of northern Africa and possibly (Pilgrim) of southern Asia in Oligocene time =MŒRITHERIOIDEA

A southern forest stock adapted to forested lowlands. Represented by the *Deinotherium* of northern and central Africa and of southern Eurasia; known from more abundant remains in Miocene to Middle Pliocene time =DEINOTHERIOIDEA

A northern stock, adapted to lowlands, to savannas, and to forests, with better developed limbs and powers of wide migration. Represented from the Lower Oligocene of northern Africa to the Miocene-Upper Pleistocene of Eurasia and North and South America =MASTODONTOIDEA

A stegodont-elephant stock, adapted to plains, savannas, and steppes; of browsing (forest) or grazing (plains) habits, also with powers of wide migration. Represented from the Lower Pliocene of southern Asia to the Pleistocene of North America and the Pleistocene and Recent of southern Asia and of Africa[1] =ELEPHANTOIDEA[2]

These four[2] great primary stocks of Eocene time, and probably other stocks still to be discovered, gave off from two to six branches each, so that the Proboscidea, as a whole, from Upper Eocene time onward are not two branched, or *diphyletic*, as formerly expressed in the adoption of only two genera, *Elephas* and *Mastodon*, but many branched or *polyphyletic*. Species of Mœritheres and Deinotheres remained in Africa and southern Eurasia; whereas the mastodonts and elephants, forest and savanna browsers and grazers of the plains, steppes, and forests, were the long distance travelers and either from an African or from an Asiatic homeland center of origin and adaptive radiation in Eocene time reached all the continents of the world, except Australia, in Miocene and Pliocene times.

Always intelligent, resourceful, independent, adaptive, well defended from their enemies of all kinds, we know at present of *seventeen*[3] entirely distinct main branches of proboscideans several of which persisted into Upper Pliocene if not into Pleistocene time, when they were overtaken by the worldwide elimination of the larger Mammalia. Only two branches, namely, the Loxodontines and the Elephantines, survive at the present time.

[1](Osborn, 1934) Plio-Pleistocene ancestors of *Archidiskodon* and *Palæoloxodon* recently discovered in South Africa (see p. 25).
[2](Osborn, 1935) The STEGODONTOIDEA superfam. nov. separated from the Elephantoidea as a distinct stock.
[3](1935) See footnotes on pages 27 and 30.

4. ORDINAL, SUBORDINAL–SUPERFAMILY, FAMILY, SUBFAMILY–PHYLETIC, GENERIC-PHYLETIC CHARACTERS EMPLOYED IN THE PHYLOGENETIC CLASSIFICATION OF THE PROBOSCIDEA

The ORDER PROBOSCIDEA is distinguished by the following characters common to all its members: (1) A pair of second upper and lower incisors greatly enlarged and originally opposed as feeding organs, a function which resulted in the loss of both the first and third pairs of incisors and in the hypertrophy of the second pair, I^2–I_2; (2) originally tetrabunodont to hexabunodont superior and inferior grinding teeth; (3) originally pentadactyl feet with subequal distribution of weight on all five digits.

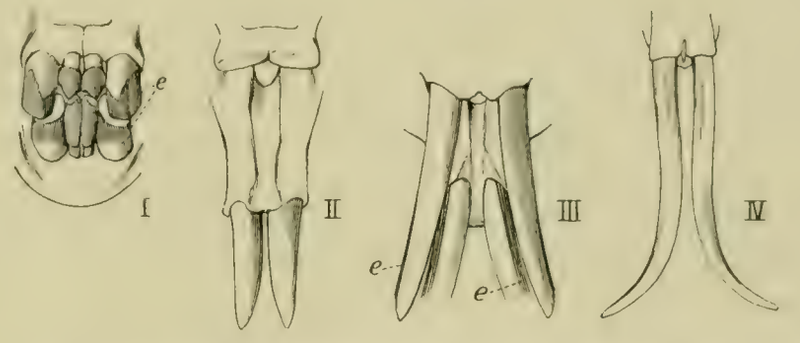


FIG. 4. FUNDAMENTAL ARRANGEMENT OF THE CUTTING TEETH, I^2–I_2, NAMELY, THE SECOND SUPERIOR AND INFERIOR INCISORS, IN FOUR SUBORDERS OR SUPERFAMILIES OF THE PROBOSCIDEA. AFTER OSBORN, 1921.515, FIG. 1, P. 3.

I. *Mœritherium* type (MŒRITHERIOIDEA): Median incisors, I^1–I_1, persisting; second incisors, I^2–I_2, opposed, as in the Rodentia, front encased in enamel.

II. *Deinotherium* type (DEINOTHERIOIDEA): Superior incisors entirely aborted; inferior incisors (probably I_2) downturned and retroverted.

III. *Rhynchotherium* type (MASTODONTOIDEA): I^2–I_2, tusks downturned, laterally compressed, partly covered with enamel band (*e*).

IV. *Elephas* type (ELEPHANTOIDEA), including Elephants, Loxodonts, Mammoths, etc., with inferior incisors, I_2, reduced or aborted, superior incisors, I^2, gradually losing enamel, typically upturned, used both as fighting and as feeding organs.

On this primary *ordinal* constitution the Proboscidea radiated adaptively into all habitats known to the herbivorous quadrupeds, namely, (*a*) fluviatile, lowland, swamp, and forest, (*b*) forest border, (*c*) plains and upland habitats, with their accompanying vegetation, softer and harder kinds of food, and reactions of the feet and limbs to the modes of locomotion corresponding to habitats *a*, *b*, *c*.

SUBORDERS—SUPERFAMILIES AS PROPOSED BY OSBORN

SUPERFAMILY RANK.—As regards the subordinal separation or rank of the four[1] primary divisions of the Proboscidea which have been discovered up to the present time, these divisions are certainly far more profound than those of the four suborders of the Rodentia, namely: I. SCIUROMORPHA, II. MYOMORPHA, III. HYSTRICOMORPHA, IV. LAGOMORPHA, which are separated from each other not by modifications in the paired incisor, I^2-I_2, function, but by fairly profound muscular adaptations in the mechanism of the jaws. The four primary divisions of the Proboscidea are also far more profound than Osborn's main divisions of the Perissodactyla, namely: I. TITANOTHERIOIDEA, II. HIPPOIDEA, III. TAPIROIDEA, IV. RHINOCEROTOIDEA, which are distinguished by profound differences in the fundamental pattern of the grinding teeth and by adaptive divergence in the original *tetradactyl* manus and pes.

[1]See footnotes on pages 19 and 22.

Therefore the I. MŒRITHERIOIDEA, II. DEINOTHERIOIDEA, III. MASTODONTOIDEA, and IV. ELEPHANTOIDEA are separated from each other by adaptive divergences in the function of the upper and lower incisor teeth which exceed in their coadaptive results those in the subordinal divisions of any other order of ungulates. If the Mœritheres and Deinotheres had lived in the time of Linnæus, it is doubtful whether he would have united them in the same order with the mastodonts and elephants which are of more obvious affinity to each other.

I. MŒRITHERIOIDEA.—Renewed study of *Mœritherium* by Osborn and Matsumoto entirely confirms Andrews' original opinion that *Mœritherium* belongs in the order Proboscidea, as well as Osborn's opinion that it stands very far apart from the other proboscideans and is not directly or indirectly ancestral to either of the other three groups. The enlargement of the second upper and lower incisor teeth into mutually abrading tusks, girdled with enamel, presents a firm ground of affinity with a still unknown primitive Lower Eocene proboscidean stem form. There the resemblance ends. These Mœritheres had no proboscis. The face, of brachyopic type, is markedly abbreviated. The cranium is elongated. Thus the facial and cranial proportions are analogous to those of the Sirenia. The upper grinding teeth are bilophodont, pointing to a tetrabunodont ancestry, and different from the bunomastodont grinders of *Palæomastodon*, which point to a hexabunodont ancestry. The lower grinders exhibit a rudimentary third crest. Andrews' opinion that the Mœritheres were amphibious is probably correct.

II. DEINOTHERIOIDEA.—All agree that these animals were chiefly browsers and partly amphibious in habit, in this respect resembling the Mœritheres but differing in the entire loss of the superior incisor teeth. Early loss of the superior tusks released the inferior. In the downturning of the inferior tusks the Deinotheres are paralleled by the Rhynchorostrinæ among the Mastodontoidea. In skull form and in limb and foot structure the Deinotheres parallel the true proboscideans. They diverge very widely from proboscideans in the evolution of the upper and lower grinding teeth. The primitive Deinotheres present simple, bilophodont grinders, similar to those of *Mœritherium*, and are progressively trilophodont. The upper grinders attain a stage which parallels the molar pattern of the tapir (*Tapirus*) among the perissodactyls, but which shows a tendency to the trilophodont structure characteristic of the primitive mastodonts and elephants.

III. MASTODONTOIDEA.—The fundamental character of the front teeth in this superfamily is seen in primitive members of the Rhynchorostrinæ and Longirostrinæ, namely: (1) Second superior incisors enlarged, downturned, divergent, with enamel band on outer side only; (2) second inferior incisors downturned (as in Deinotheres) with enamel band on outer side (Rhynchorostrinæ) or procumbent with no enamel band (Longirostrinæ).

The important functional distinction of the Mastodontoidea is that for a very long period of time the upper tusks abraded the outer side of the lower tusks; this probably explains the retention of the superior enamel band. In certain lines (Longirostrinæ) the procumbent lower incisors persist and the upper incisors retain their primitive downcurved position as in *Phiomia*. In other lines (Mastodontinæ, Brevirostrinæ) the lower incisors practically cease to function; the upper incisors finally turn upward and inward, but may retain the enamel band for a long period (Mastodontinæ, *fide* Schlesinger, and Notorostrinæ, *vide Cordillerion andium*).

A distinctive character of the grinding teeth of the Mastodontoidea is evidence of the descent from a tetrabunodont ancestral grinder (i. e., without intermediate tubercles or 'conules'), as is the case with the tetrabunodont ancestral type of Mœritheres and Deinotheres. The rudiments of ancestral conules gave rise to various

trefoils or paired median outgrowths or crests, so characteristic of all the Bunomastodontidæ whether beak jawed (Rhynchorostrinæ), or long jawed (Longirostrinæ), or short jawed (Brevirostrinæ). In each of these subfamilies the grinders independently undergo a more or less closely parallel evolution, evolving single trefoils in Upper Oligocene and in Miocene time, and double trefoils in Pliocene time.

Unlike the Mœritheres and Deinotheres, the three intermediate molars (i. e., fourth premolar and first and second true molars) invariably become trilophodont, while the third true molars become tetralophodont. At this point there is a divergence into (1) Mastodontidæ, purely forest living, brachyodont, with simply crested teeth, in which the intermediate molars are persistently trilophodont, with arrested trefoils, and into (2) Bunomastodontidæ, which pass into tetralophodonty and polylophodonty in some lines, with evolving trefoils. The grinder evolution is adapted to a leaf-browsing habit, in distinction to the prevailing grazing habit developed among the elephantoids. The development of hypsodonty, and chœrodonty (Schlesinger), among these (longirostrine and brevirostrine) browsers is analogous to that in the hippopotami and the hypsodont suillines.

IV. ELEPHANTOIDEA.—One prime distinction in this superfamily is the very early complete loss of the lower incisor teeth, accompanied by the early development of the upper incisors into horizontal or upturned tusks finally devoid of enamel except at the tips in the young stage. Vestigial enamel bands are recorded in early stages of the Stegodonts. A second distinctive character is the absence of conule development into trefoils, so characteristic of the mastodontoids, and the early tendency to form evenly transverse, more or less mamillate, crests which become in the highest degree hypsodont and polylophodont in adaptation to chiefly grazing habits.

It has been assumed by practically all palæontologists that the Elephants were descended from the Stegodonts. This assumption now proves to be erroneous, for neither the *Stegodon* grinding tooth with enamel valleys closed at the bottom, nor the *Stegodon* cranium with its extremely short face, can give rise to the elephantoid molar or the face of the elephantoid cranium. The earliest elephants known (1934) are the primitive species of *Archidiskodon* and of *Palæoloxodon* of the Plio-Pleistocene of South Africa. The Stegodonts were of independent origin and formed an independent parallel branch terminating in the highly specialized *Elephas* [= *Stegodon*] *auroræ* Matsumoto from the Upper(?) Pliocene of Mt. Tomuro, Japan, now (1935) separated by Osborn as the STEGODONTOIDEA superfam. nov.

Chief Head and Dental Forms of four of the Suborders (I-V) of the Proboscidea

Fig. 5. (1) Mœritherioidea, one-twelfth natural size. (2) Deinotherioidea, (3) Mastodontoidea, and (4) Elephantoidea, all one-fiftieth natural size

FAMILIES OF PROBOSCIDEA AS ORIGINALLY PROPOSED

Only one *family* up to recent time[1] has been proposed in three of the four[1] suborders or superfamilies of the Proboscidea. In the Mastodontoidea there are two[2] families, the Mastodontidæ and the Bunomastodontidæ.

I. MŒRITHERIOIDEA Osborn, 1921.515, p. 2. Family: Mœritheriidæ Andrews, 1906, p. 99.

II. DINOTHERIOIDEA Osborn, 1921.515, p. 2 [=Deinotherioidea of the present Memoir]. Family: Curtognati [=Curtognathidæ] Kaup, 1833.4, p. 516; Dinotheridæ Bonaparte, 1845 (*fide* Palmer, 1904, p. 738), Dinotheriidæ Bonaparte, 1850; Dinotheridæ Zittel, 1891–1893, p. 454; Dinotheriidæ Osborn, 1918.468, p. 134 [=Curtognathidæ of the present Memoir].

NOTE.—The superfamily Deinotherioidea as well as the family Deinotheriidæ are partly anticipated in the term Curtognati Kaup (Kaup, Bull. Soc. Géol. de France, V, 1834, p. 444): "*Curtognati.*—M. Kaup a reçu de nouveaux ossemens d'Eppelsheim, et a reconnu que le *Dinotherium medium* était véritablement bien différent du *D. giganteum.* M. Kaup a pu faire aussi quelques corrections et additions à sa description du *Dinotherium.* Il pense que ses deux énormes défenses ne lui servaient pas seulement pour extraire des racines de la terre, mais encore, comme à la morse, pour l'aider à mouvoir son corps si lourd. D'après la forme des os intermaxillaires, cet animal devait avoir une trompe pour porter la nourriture à sa bouche. Il est à placer entre les Mastodontes et les Bradypus, et il formerait une famille particulière à laquelle M. Kaup donne le nom de *Curtognati.* Elle serait caractérisée par la mâchoire inférieure courbée vers le bas, et les deux défenses dirigées vers le bas et en arrière (*N. Jahrb. f. Mineral. Geognosie*, etc., 1833 [1833.4], cah. 5, p. 509 avec 1 pl.)."

III. MASTODONTOIDEA Osborn, 1921.515, p. 2. Family: Mastodonadæ Gray, 1821, p. 306 (*fide* Palmer 1904, p. 752); Mastodontidæ Girard, 1852, pp. 326, 328; Mastodontidæ Osborn, 1918.468, p. 134, including the Palæomastodontidæ of Andrews, 1906, p. 130.

Osborn has recently added the following family: Bunomastodontidæ, 1921.515, p. 2, to include (1921–1922) all the bunomastodonts which develop the intermediate conules into, first, single and, then, double trefoils; also a very important branch with several side branches of mastodonts in which the lophs are transformed into well-defined transverse crests paralleling the zygolophodont condition of the Stegodonts, and perhaps giving off a branch into the Stegodontinæ. The Bunomastodontidæ constitute a very distinct family, from which arose several subfamilies also widely separated from each other.

IV. ELEPHANTOIDEA Osborn, 1921.515, p. 2. Family: Elephantidæ Gray, 1821, p. 305 (*fide* Palmer, 1904), p. 740 (=Elephasideæ Lesson, 1842, p. 156; Elephantidæ Bonaparte, 1838, p.112, and 1850; Girard, 1852; Zittel, 1891, p. 458; Osborn, 1910.346, p. 558).

The above *five families* of the Proboscidea are distinguished from each other by profound modifications in the fundamental structure of the grinding teeth. These differences in fundamental structure are almost as profound as those which separate the *eight families* of the order Perissodactyla, or the *seven superfamilies* of the order Rodentia, e. g., APLODONTOIDEA, SCIUROIDEA, CASTOROIDEA, GEOMYOIDEA, MYOIDEA, ANOMALUROIDEA, BATHYERGOIDEA.

It is noteworthy that the giant Proboscidea *closely parallel* the humble Rodentia in the profound modes of evolution of the grinding teeth.

[1]See footnotes on pages 19 and 22.

[2](Osborn, 1934) To these two families have been added the Serridentidæ fam. nov. and the Humboldtidæ fam. nov.

SUBFAMILIES OF PROBOSCIDEA AS ORIGINALLY PROPOSED

The following seventeen[1] subfamily divisions of the Proboscidea have successively been proposed, as explained in full chronological detail in Chapters II-XX of the present Memoir:

I. MŒRITHERIOIDEA:

1. Mœritheriini—Herluf Winge, 1906, p. 172; Mœritheriinæ Winge-Osborn, 1923.601, p. 1.

II. DINOTHERIOIDEA:

2. Dinotherina—Bonaparte, 1841, p. 253, Dinotheriina—Bonaparte, 1850; Dinotheriini—Herluf Winge, 1906, p. 172; Dinotheriinæ—Osborn, 1910.346, p. 558 [=Deinotheriinæ of the present Memoir].

III. MASTODONTOIDEA:

3. Mastodontina—Brandt, 1869, p. 35; Mastodontinæ—Osborn, 1910.346, p. 558.

   Bunomastodontinæ—Osborn, 1918.468, p. 134. Replaced by Bunomastodontidae—Osborn, 1921.515, p. 2.

4. Longirostrinæ—Osborn, 1918.468, p. 136.
5. Rhynchorostrinæ—Osborn, 1918.468, p. 136.
6. Brevirostrinæ—Osborn, 1918.468, p. 136.
7. Serridentinæ (*T. serridens* phylum, Osborn, 1921.515, p. 8)—Osborn, 1921.526, p. 330.
8. Notorostrinæ—Osborn, 1921.526, p. 330, distinguished and defined.
9. Zygolophodontinæ—Osborn, 1923.601, p. 1, to include the species: *Zygolophodon tapiroides*, *Z. turicensis*, *Z. virgatidens*, *Z. borsoni*, and *Z. pyrenaicus*, as more fully defined below, which were mistakenly confused with the Serridentinæ by Osborn (1921.515).
10. Platybelodontinæ—Borissiak, 1928, p. 119.
11. Amebelodontinæ—Barbour, 1929.2, p. 139.
12. Tetralophodontinæ—van der Maarel, 1932, p. 108.
13. Humboldtinæ—subfam. nov.

IV. ELEPHANTOIDEA:

14. Stegodontinæ—Osborn, 1918.468, p. 135, to include the Stegodonts of southern Asia.
15. Loxodontinæ—Osborn, 1918.468, p. 135, to include the phylum of African elephants.
16. Elephantina—Bonaparte, 1838, p. 112, 1850; Elephantini—Winge, 1906, p. 172; Elephantinæ—Osborn, 1910.346, p. 558, 1918.468, p. 135.

    Euelephantinæ—Osborn, 1918.468, p. 136. Abandoned as invalid, because the genus *Euelephas* is invalid.

17. Mammontinæ—Osborn, 1921.515, pp. 1, 14.

GREAT ANTIQUITY.—The above *seventeen*[1] subfamilies have been separated from each other for very long periods of geologic time, many of them since Lower and Middle Eocene times, others since Oligocene time. This very ancient geologic and adaptive habitudinal radiation is especially characteristic of the subfamilies included within the Mœritherioidea and the Deinotherioidea as well as of the eleven[1] subfamilies included within the Mastodontoidea. As regards the Elephantoidea, it would appear that the Stegodontinæ, the Loxodontinæ, and the Elephantinæ had already widely radiated in Miocene time, but we do not as yet know when the Mammontinæ were given off from their closest relatives, the Elephantinæ.

[1](1935) See Appendix of the present Volume I for PALÆOMASTODONTINÆ subfam. nov., based on the genus *Palæomastodon* Andrews, and GNATHABELODONTINÆ, based on *Gnathabelodon* Barbour, also the removal of *Stegolophodon* from the Stegodontidæ, subfamily Stegodontinæ, to the new subfamily STEGOLOPHODONTINÆ, making twenty subfamilies in all, fourteen of which are included within the superfamily Mastodontoidea.

Subfamily Divergence.—Whereas the *families* of Proboscidea are distinguished from each other by profound modifications in the fundamental structure of the grinding teeth, the *subfamilies* of Proboscidea are distinguished mainly by *secondary adaptations of the grinding teeth* correlated with profound adaptations in the upper and lower incisor teeth. For example, compare the lower incisor teeth in the Mastodontinæ, the Longirostrinæ, the Rhynchorostrinæ, the Brevirostrinæ, and the Notorostrinæ and observe how profoundly different each is from the other. This adaptation or loss of the lower incisor teeth is correlated with important adaptations of the upper teeth and finally with the structure of the grinding teeth. Here the *principle of adaptive compensation* is observed; e. g., in the Rhynchorostrinæ, with their well-developed lower tusks, the grinding teeth remain excessively simple, whereas in the Brevirostrinæ, with the *loss* of the lower tusks, the grinding teeth become excessively complex.

The phylogenetic basis of this *seventeen-fold*[1] subfamily division is to separate clearly every direct line of descent of species and genera from every other direct line of descent; the subfamilies are observed as vertically ascending ancestral lines which may be subdivided into one or more generic stages.

Contrast with Cope.—This vertical phylogenetic use of the subfamily by Osborn (1918.468, pp. 133, 134) presents the most direct contrast to the system of Cope: "Cope's family classifications were morphological and horizontal rather than phylogenetic and geological. Finding one or more single characters possessed in common at certain horizontal periods of geologic time by mammals in different lines of evolutionary descent, he seized on these common characters as convenient keys to classification. . . . I have reached the opinion that Cope's method of morphological classification is untenable, that the only true and permanent classification is phylogenetic. . . . Sometimes the subfamilies proposed by zoologists conform to the phyletic lines discovered by paleontologists; sometimes they do not."

GENERIC VALUES IN PROBOSCIDEA

Inasmuch as the Order PROBOSCIDEA is distinguished by profound adaptations of the incisor teeth, the Suborders by profound modifications of the incisors, I^2-I_2, the Families by profound adaptations of the grinding teeth, the Subfamilies by secondary adaptations of the upper and lower incisor teeth and compensatory adaptations of the grinding teeth, it remains to distinguish the Genera by *successive stages in the evolution of these secondary and compensatory adaptations.*

For example, the four genera of the phylum Mastodontinæ in descending order:

Pleistocene Genus *Mastodon:* Lower incisor tusks small, variable; upper tusks large, without enamel.

Pliocene Genus *Pliomastodon:* Lower incisor tusks intermediate; upper tusks rounded, without enamel.

Miocene Genus *Miomastodon:* Lower incisor tusks intermediate; upper tusks upcurved with broad enamel band.

Oligocene Genus *Palæomastodon:* Lower and upper tusks unknown; upper tusks probably downturned with broad enamel band.

Or, for example, the three genera of the phyla Tetralophodontinæ, Longirostrinæ, and Amebelodontinæ in descending order:

Miocene Genus *Tetralophodon*: Lower tusks procumbent; upper tusks downturned. Intermediate grinders tetralophodont.

Miocene Genus *Trilophodon:* Upper tusks downturned with enamel band. Intermediate molars trilophodont.

Oligocene Genus *Phiomia:* Lower incisors procumbent without enamel; upper incisors fighting weapons with enamel band. Intermediate molars trilophodont.

[1]See footnotes on pages 19 and 27.

Thus in the phylogenetic classification of the Proboscidea the GENUS *embraces and distinguishes the successive stages of adaptation and evolution of single or multiple characters, as observed in ascending geologic horizons.*

Among GENERA the phenomena of parallelism, of convergence, and of homoplasy are especially rife. For example, the superior incisors of *Mastodon*, of *Anancus*, and of certain species of *Cordillerion* tend to lose their enamel and to become upturned and outwardly arched so as to mimic each other closely, and there occurs a correlated homomorphy or parallelism in skull structure. Most confusing, however, to the early students (such as Falconer) of the Proboscidea was the parallel evolution of the trilophodont intermediate molars, e. g., Dp 3 $\frac{3}{3}$, M 1 $\frac{3}{3}$, M 2 $\frac{3}{3}$, which arose separately in *Phiomia*, in *Palæomastodon* (rudimentary), in *Anancus*, and in *Stegodon*. In fact, it is certain that in many distinct branches of proboscideans trilophodonty was independently developed. Similarly the tetralophodont condition of the intermediate molars arose independently in *Tetralophodon* and in *Anancus*, also in the ancestral Stegodonts and ancestors of all the true Elephantoidea. The third form of generic parallelism is the independent evolution in all the genera of the bunomastodonts of *single trefoils* followed by *double trefoils;* for example, as in the transition from *Trilophodon angustidens* (single trefoils) to *Tetralophodon longirostris* (double trefoils), or in the transition from *Cordillerion andium* (single trefoils) to *Cuvieronius humboldtii* (double trefoils).

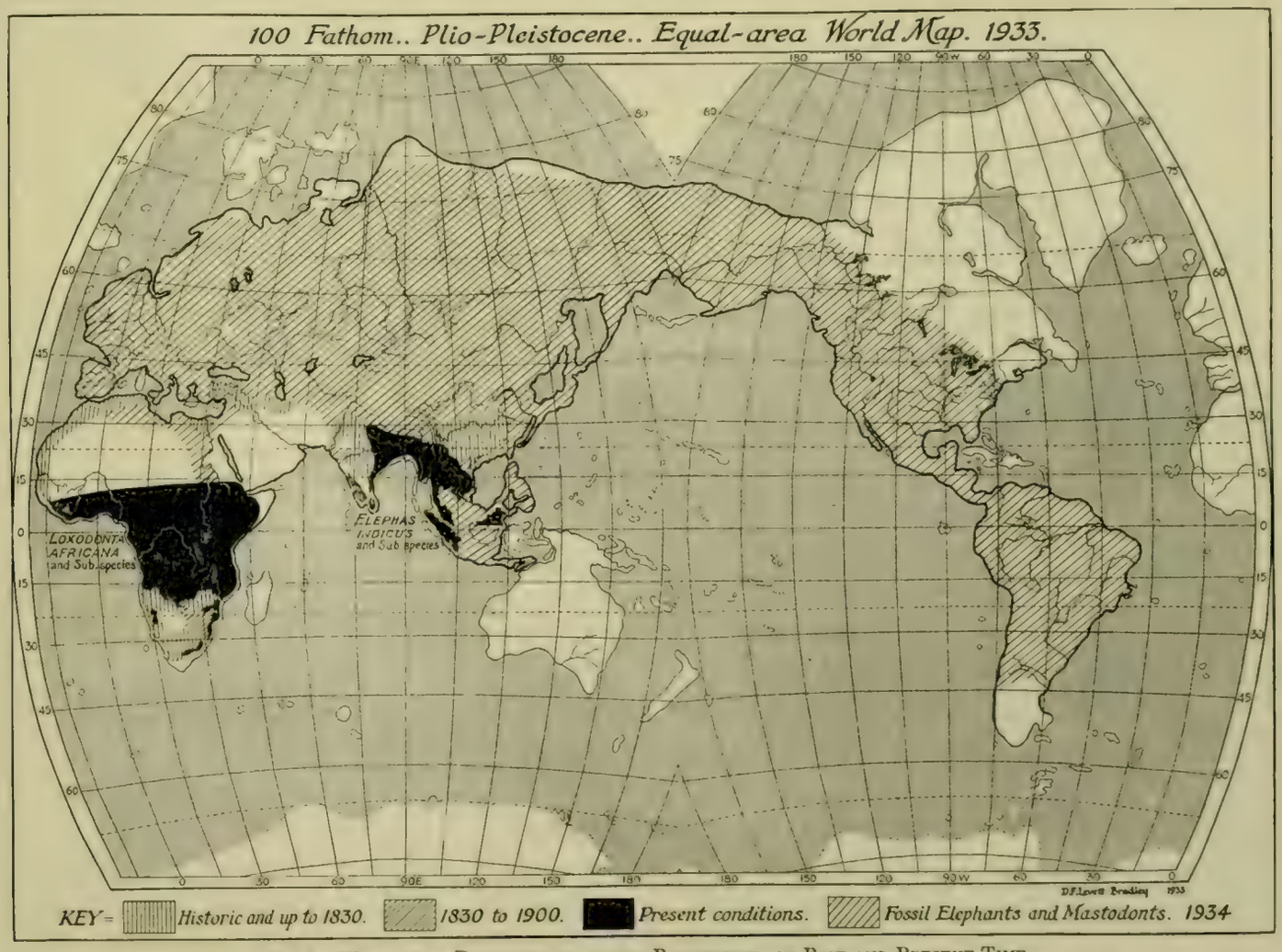


Fig. 6. WORLDWIDE DISTRIBUTION OF THE PROBOSCIDEA IN PAST AND PRESENT TIME

AFRICAN ELEPHANT: After Blanc, 1897; Bocage, 1890; Buckley, 1876; Chapman, 1868; Chubb, 1909-1919; Claridge, 1915; Cox, 1900; Heilprin, 1887; Hippolyte, 1907; Johnston, 1907; Maydon, 1932; Roosevelt and Heller, 1914; Schultze, 1907; Sclater, 1900.

INDIAN ELEPHANT: After Bartholomew, 1911; Blanford, 1888-1891; Blyth, 1872; Bishop, 1921; Champion, 1928; Hornaday, 1885; Hunter, 1868; Jerdon, 1874; Laufer, 1925; Lydekker, 1900-1908; Sanderson, 1907; Sclater, 1899.

5. HARMONY OF LINNÆAN AND PHYLOGENETIC CLASSIFICATION EXPRESSING OUR KNOWLEDGE UP TO THE CLOSE OF THE YEAR 1933

Thus by applying the principle of adaptive radiation in geologic time we find it is practicable to develop consistently a phylogenetic classification out of the Linnæan system which included within the order Proboscidea only the single species *Elephas indicus*. This phylogenetic system provides a consistent terminology for the main stock, its branches and subbranches, parts of which may be Anglicized for convenience as follows:

CLASSIFICATION FIRST ADOPTED (1933) BY OSBORN IN THE PRESENT MEMOIR

Osborn, 1935: This classification of the year 1933 has been recently modified by successive discoveries up to July of the year 1935. Accordingly the reader is referred to page 685 *et seq.* for the classification of 1935 which introduces new forms and new concepts of relationship and lines of descent.

ORDER **PROBOSCIDEA** (Proboscideans)—Illiger, 1811, p. 96. Upper Eocene to Recent time.

SUBORDER I. MŒRITHERIOIDEA (Mœritheres)—Osborn, 1921.515, p. 2. A primitive, amphibious, swamp-loving stock.

FAMILY MŒRITHERIIDÆ—Andrews, 1906, p. 99; Osborn, 1921.515, p. 1.

SUBFAMILY MŒRITHERIINÆ Winge-Osborn—Osborn, 1923.601, p. 1 (=Mœritheriini Winge, 1906, p. 172). Upper Eocene, Lower Oligocene of Africa.

SUBORDER II. DEINOTHERIOIDEA (Deinotheres)—Osborn, 1921.515, p. 2. Specialized, fluviatile or river border proboscideans. Mio-Pliocene.

FAMILY CURTOGNATHIDÆ—Kaup, 1833.4, p. 516.

SUBFAMILY DEINOTHERIINÆ—Osborn, 1910.346, p. 558 (=Dinotherina Bonaparte, 1841, p. 253, Dinotheriina Bonaparte, 1850; Dinotheriini Winge, 1906, p. 172). Large, river-border, fluviatile forms of southern Eurasia; throughout the Miocene to the close of the Pliocene, into the Pleistocene.

SUBORDER III. MASTODONTOIDEA[1] (Mastodonts and Bunomastodonts)—Osborn, 1921.515, p. 2. Chiefly forest and savanna browsers.

FAMILY MASTODONTIDÆ ("True Mastodonts")—Girard, 1852, pp. 326, 328 (=Mastodontidæ Osborn, 1918.468, p. 134), including Palæomastodontidæ of Andrews, 1906, p. 130. Chiefly browsers in the north temperate and boreal forests.

SUBFAMILY MASTODONTINÆ—Osborn, 1910.346, p. 558 (=Mastodontina Brandt, 1869, p. 35). Springing from unknown African ancestors; Oligocene of North Africa; including *Miomastodon* and *Pliomastodon* (Miocene and Pliocene of Holarctica), and *Mastodon americanus* (Pleistocene forests of North America). Persistent forest browsers. Grinders tetrabunodont, sublophodont, lacking trefoils.

SUBFAMILY ZYGOLOPHODONTINÆ ("Yoke-toothed Mastodonts")—Osborn, 1923.601, p. 1. Browsers of the temperate forests of Europe and Asia, including *Turicius turicensis*, *T. tapiroides*, T. *virgatidens*, *Zygolophodon pyrenaicus*, terminating with *Z. borsoni*. Miocene to Upper Pliocene. Grinding teeth polybunodont to purely lophodont, lacking trefoils.

[1](1935) To the Mastodontoidea have been added two new families, the SERRIDENTIDÆ and the HUMBOLDTIDÆ, and two new subfamilies, the PALÆOMASTODONTINÆ and the STEGOLOPHODONTINÆ (see Appendix of the present Volume for final classification).

FAMILY BUNOMASTODONTIDÆ ("True Bunomastodonts")—Osborn, 1921.515, p. 2. Arising from forms similar to *Phiomia* of North Africa, probably lowland and swamp browsers, radiating into nine[1] subfamilies. Oligocene to Lower Pleistocene. Grinders provided with single or double trefoils—hence "bunomastodont."

SUBFAMILY LONGIROSTRINÆ ("Long-jawed Bunomastodonts")—Osborn, 1918.468, p. 136. Long-jawed typical bunomastodonts, arising in North Africa (*Phiomia*[2]), migrating all over North Africa, southern Europe, Asia, and North America north of Mexico; including *Trilophodon*. Grinding teeth originally bunodont, trilophodont. Central conules.

SUBFAMILY AMEBELODONTINÆ (typical "Shovel-tuskers")—Barbour, 1929.2, p. 139. Including the shovel-tuskers of Nebraska. Typified by *Amebelodon fricki* Barbour.

TETRALOPHODONTINÆ ("Four-ridge-crested Bunomastodonts")—van der Maarel, 1932, p. 108. Typified by *'Mastodon' longirostris* Kaup and *Tetralophodon bumiajuensis*, van der Maarel. Second molars with four ridge-crests, i.e., tetralophodont.

SUBFAMILY SERRIDENTINÆ ("Medium-jawed Bunomastodonts")—Osborn, 1921.526, p. 330. Modifying the trefoils to the outer walls. Grinding teeth sublophodont; upper and lower incisor teeth as in the Longirostrinæ. Upper Miocene to Upper Pliocene of North America (typified by *Serridentinus serridens* and *S. productus*); Upper Pliocene of Texas, of Florida, and of Guatemala; Miocene of Mongolia (*Serridentinus mongoliensis*); Upper Miocene of India (*Serridentinus browni*); Pliocene of North China (*Serridentinus lydekkeri*).

PLATYBELODONTINÆ ("Flat-tuskers")—Borissiak, 1928, p. 119. Typified by *Platybelodon danovi* Borissiak, including *P. grangeri* of Mongolia and *Torynobelodon barnumbrowni* of Nebraska. Extremely broad shovel-tusks.

SUBFAMILY RHYNCHOROSTRINÆ ("Beak-jawed Bunomastodonts")—Osborn, 1918.468, p. 136. With powerful downturned upper and lower tusks. Known only in the southern United States and northern Mexico. Typified by *Rhynchotherium tlascalæ* of Mexico, *R. euhypodon*, *R. brevidens*.

SUBFAMILY NOTOROSTRINÆ (Notorostrines)—Osborn, 1921.526, p. 330. First known in the Andean region of South America (*Cordillerion andium*); subsequently discovered in the southern United States and Mexico. Distinguished by the loss of the lower tusks, the abbreviation of the lower jaw, the spiral tusks (*C. andium*).

HUMBOLDTINÆ ("Humboldtines")—new subfamily described in the present Memoir. Typified by *Cuvieronius humboldtii* with straight or upturned tusks without enamel; molar enamel ptychoid, highly folded. Includes *Stegomastodon mirificus*.

SUBFAMILY BREVIROSTRINÆ ("Short-jawed Bunomastodonts")—Osborn, 1918.468, p. 136. Springing from the same stock as the Longirostrinæ; distinguished by the rapid abbreviation of the lower jaw, by the early loss of the inferior tusks, by the hypsodonty and labyrinthine multiple trefoil pattern of the grinding teeth. First known in Europe (*Anancus arvernensis*), thence wandering into Asia (*Pentalophodon sivalensis*, *Synconolophus dhokpathanensis*); not known to enter North America.

[1](Osborn, 1935) Seven subfamilies by removal of the Serridentinæ, Platybelodontinæ, and Humboldtinæ and the addition of the Gnathabelodontinæ.
[2]*Phiomia* now removed to the Amebelodontinæ (see Appendix of the present Volume for final classification).

SUBORDER IV. ELEPHANTOIDEA[1] (Elephants and Mammoths of Africa, Eurasia, and North America)—Osborn, 1921.515, p. 2. Browsers (Stegodontinæ), chiefly tree browsers (Loxodontinæ), general browsers and grazers (Elephantinæ), browsers and grazers (Mammontinæ).

FAMILY ELEPHANTIDÆ—Gray, 1821, p. 305 (*fide* Palmer, 1904, p. 740); Osborn, 1910.346, p. 558.

SUBFAMILY STEGODONTINÆ (Stegodonts)—Osborn, 1918.468, p. 135. Original members closely similar to, and perhaps identical with, certain of the Zygolophodontinæ of Europe. Dwellers in the very warm forest and savanna regions of southern Eurasia and western India. Grinders rapidly multiplying crests, but persistently short crowned (brachyodont). Known from the Middle Pliocene (*Stegolophodon cautleyi*) to the Lower Pleistocene (*Stegodon insignis, S. ganesa*) of India.

SUBFAMILY LOXODONTINÆ (Loxodonts)—Osborn, 1918.468, p. 135. Distinguished by long narrow grinding teeth with relatively few crests; embracing *Loxodonta africana* and all the species of African elephants, the cranial varieties of *Loxodonta antiqua* [=*Hesperoloxodon*], Upper Pliocene to Upper Pleistocene, *Loxodonta namadica* [=*Palæoloxodon*] of India which radiated widely over Africa and wandered all over southern Eurasia, attaining the tallest stature known among the elephants; also the dwarfed insular forms *Loxodonta* (*Pilgrimia*) *falconeri*, *Loxodonta* (*Pilgrimia*) *melitensis*, *Loxodonta* (*Pilgrimia*) *creticus*, *Loxodonta* (*Pilgrimia*) *cypriotes*, etc.

SUBFAMILY MAMMONTINÆ (Mammoths)—Osborn, 1921.515, p. 1. Of close original affinity to the Elephantinæ, including (*a*) the southern mammoths *Archidiskodon planifrons* and *A. meridionalis* of southern Eurasia, *A. imperator* of North America, all with broad-plated teeth and few crests; also (*b*) the northern mammoths which apparently include *Parelephas trogontherii* of western Europe, *P. columbi* and *P. jeffersonii* of North America, and the widespread woolly mammoth (*Mammonteus primigenius*) of the northern steppes.

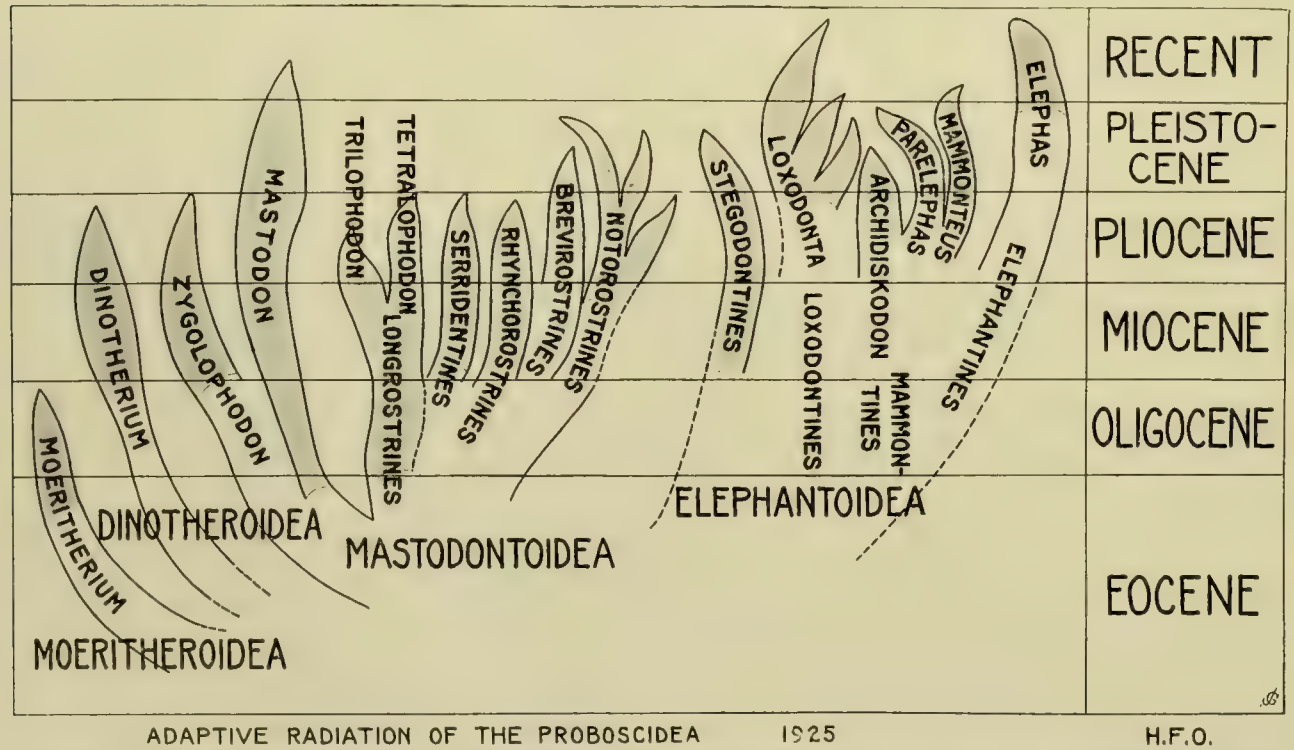


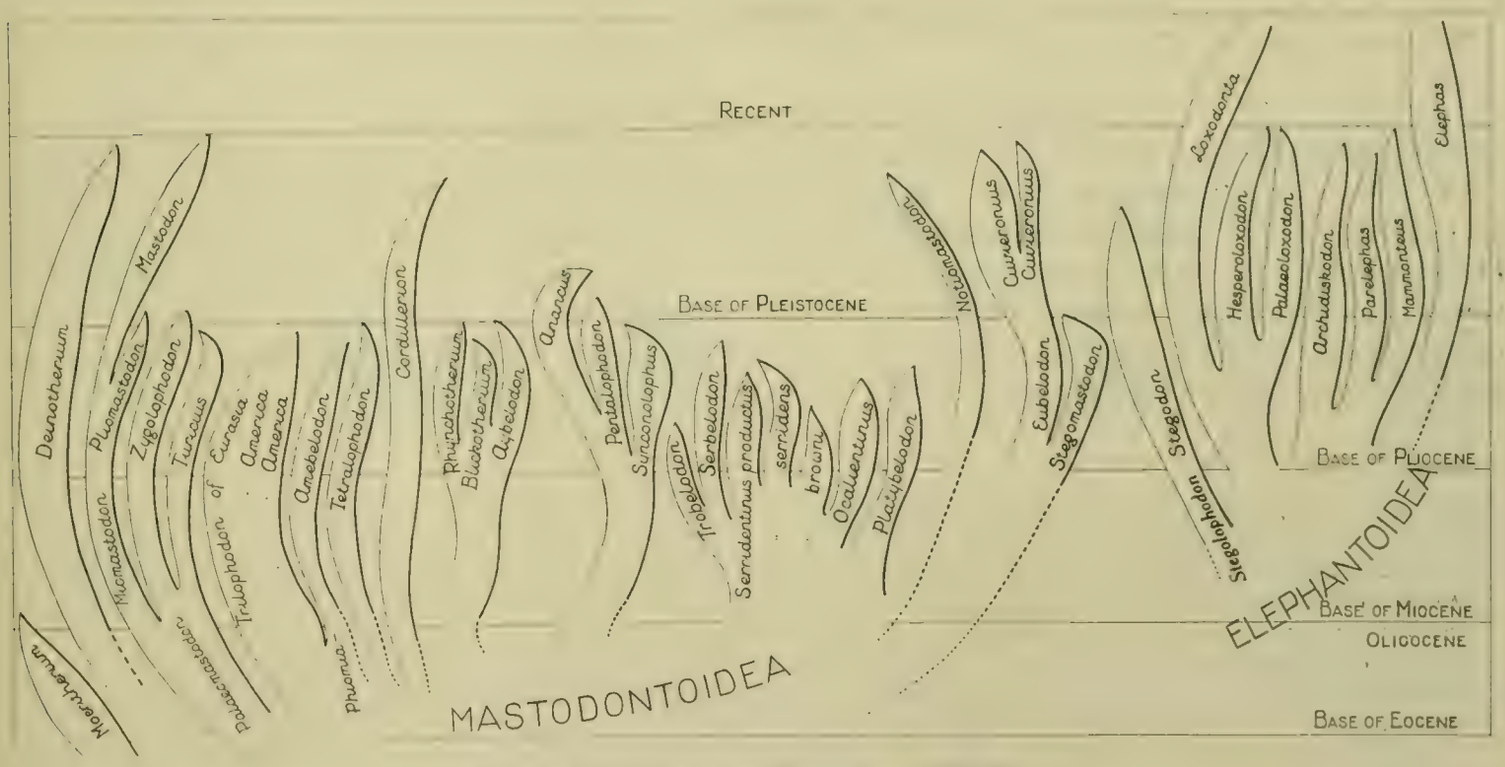
Fig. 7. Diagram showing the known and unknown stages in the Adaptive Radiation of the Proboscidea up to April, 1925. After Osborn, 1925.662, p. 21, fig. 2. Compare previous diagram of 1921 (Fig. 3 of the present Chapter II), also final diagrams of 1933–1934 (Fig. 8 opposite) and 1935 (Appendix).

[1]See footnote on page 22.

SUBFAMILY ELEPHANTINÆ ("True Elephants")—Osborn, 1910.346, p. 558 (=Elephantina Bonaparte, 1838, p. 112, 1850; Elephantini Winge, 1906, p. 172). Typified by *Elephas indicus* Linn. of India, which apparently evolved during Tertiary and Lower Pleistocene times in northern Eurasia and did not appear in southern Asia (India) and Asia Minor until the Upper Pleistocene.

To those monophyletists who cling to *Mastodon-Stegodon-Elephas* descent, this *seventeen-fold*[1] *subfamily* branching of the proboscideans is very difficult to credit until we examine in detail the anatomy of the *known* genera and species of which these branches are composed and which we soon realize make up a very small proportion of the total number of genera and species entering into this titanic order from its origin in Lower Eocene time to its great climax in Upper Pliocene and Pleistocene times. The contrast between the known and the unknown is presented graphically in the accompanying diagrams (Figs. 7 and 8).

In the succeeding pages of this Memoir the author will demonstrate that this Adaptive Radiation and Phylogenetic Classification are not imaginary but are based on the solid ground of our present knowledge. This strong statement needs several reservations, among them, the ancestry of the Elephantidæ, now traced to the summit of the Pliocene only.



ADAPTIVE RADIATION OF THE PROBOSCIDEA (1933–1934)

Fig. 8. Diagram showing the known adaptive radiation of the 37–41 generic phyla of the Proboscidea as discovered up to the year 1934. Compare previous diagrams (Figs. 3 and 7), also phylogenetic diagrams of 1935 in the Appendix.

[1]See footnote on page 27.

II. OSBORN'S THEORY (1900) AS TO THE AFRICAN ORIGIN OR CENTER OF ADAPTIVE RADIATION OF THE PROBOSCIDEA

In 1899–1900 Osborn, Tullberg, and Stehlin independently advanced the theory that Africa was the continent on which the Proboscidea originated. The original homeland of the Proboscidea is no longer in doubt; the evidence (1933) favors the geologically ancient continent of Africa.

Osborn (1900).—Until the end of the nineteenth century Asia was favored as the homeland of the Proboscidea and it is still possible, although not at present probable, that the order originated there. The reasons why Asia is not at present favored as the Proboscidea center are threefold, namely: (1) The total absence of Proboscidea in the known Upper Eocene and Lower Oligocene exposures; (2) the apparent derivation of the earliest Asiatic Proboscidea from ancestral African prototypes; (3) the Miocene appearance of African Proboscidea in Europe and North America. If the Proboscidea had originated in Asia in Eocene time they probably would have migrated into North America in Eocene or at least in Oligocene time, since the Proboscidea were great travelers. If not the original homeland or primary center, Asia certainly became a secondary homeland in which occurred the chief evolution and adaptive radiation of the family Elephantidæ. Current exploration in central Asia will probably clear up this whole problem.

Theory of the African Center.—On the contrary, Africa, which remained the "dark continent" of palæontology until the beginning of the twentieth century, was seldom regarded as a very important center of evolution and adaptive radiation of the Mammalia, despite some excellent suggestions by Rütimeyer (1888) on this subject. The first palæontologists and zoologists to make a bold claim for Africa were Osborn (1900), Tullberg (1899), and Stehlin (1900). On this subject we may refer to Osborn's addresses of 1900 (April, 1900.182, "The Geological and Faunal Relations of Europe and America during the Tertiary Period and the Theory of the Successive Invasions of an African Fauna," and July, 1900.187, "Correlation between Tertiary Mammal Horizons of Europe and America"). The following citation is from Osborn's July article (1900.187, pp. 56–58):

III. OSBORN'S THEORY OF SUCCESSIVE INVASIONS OF AN AFRICAN FAUNA INTO EUROPE

In Europe there are in the upper Eocene two classes of animals, first, those which have their ancestors in the older rocks; second, the class including certain highly specialized animals which have no ancestors in the older rocks—among these, perhaps, are the peculiar flying rodents or *Anomaluridæ*, now confined to Africa, and secondly the highly specialized even-toed ruminant types—the anoplotheres, xiphodonts and others, the discovery of which in the *Gypse* near Paris Cuvier has made famous. It is tempting to imagine that these animals did not evolve in Europe but that they represent what may be called the first invasion of Europe by African types from the Ethiopian region.

It is a curious fact that the African continent as a great theater of adaptive radiation of Mammalia has not been sufficiently considered. It is true that it is the dark continent of palæontology for it has practically no fossil mammal history; but it by no means follows that the Mammalia did not enjoy there an extensive evolution.

Although it is quite probable that this idea has been advanced before, most writers speak mainly or exclusively of *the invasion of Africa by European types*. Blanford and Allen it is true have especially dwelt upon the likeness of the Oriental and Ethiopian fauna but not in connection with its antecedent cause. This cause I believe to have been mainly an invasion from south to north correlated with the northern extension of Ethiopian climate and flora during the Middle Tertiary. It is in a less measure due to a migration from north to south. Let us therefore clearly set forth the hypothesis of *the Ethiopian region or South Africa as a great center of independent evolution* and as the source of successive northward migrations of animals, some of which ultimately reached even the extremity of South America—I refer to the Mastodons. This hypothesis is clearly implied if not stated by Blanford in 1876 in his paper upon the African element in the fauna of India.

The first of these migrations we may suppose brought in certain highly specialized ruminants of the upper Eocene, the anomalures or peculiar flying rodents of Africa; with this invasion may have come the pangolins and aard varks, and possibly certain armadillos, *Dasypodidæ*, if M. Filhol's identification of *Necrodasypus* is correct. A second invasion of great distinctness may be that which marks the beginning of the Miocene when the mastodons and dinotheres first appear in Europe, also the earliest of the antelopes. A third invasion may be represented in the base of the Pliocene by the increasing number of antelopes, the great giraffes of the Ægean plateau, and in the upper Pliocene by the hippopotami. With these forms came the rhinoceroses with no incisor or cutting teeth, similar to the smaller African rhinoceros, *R. bicornis*. Another recently discovered African immigrant upon the Island of Samos in the Ægean plateau is *Pliohyrax* or *Leptodon*, a very large member of the Hyracoidea, probably aquatic in its habits, indicating that this order enjoyed an extensive adaptive radiation in Tertiary times.

It thus appears that the Proboscidia, Hyracoidea, certain edentata, the antelopes, the giraffes, the hippopotami, the most specialized ruminants, and among the rodents, the anomalures, dormice, and jerboas, among monkeys the baboons, may all have enjoyed their original adaptive radiation in Africa; that they survived after the glacial period, only in the Oriental or Indo-Malayan region, and that this accounts for the marked community of fauna between this region and the Ethiopian as observed by Blanford and Allen.

In his April and July, 1900, articles, Osborn printed two world maps (Figs. 9, 10) illustrating his theories regarding Africa and Asia; the Africa theory of Osborn was confirmed in 1901; the Asia theory of Osborn was confirmed in 1922.

Zoogeographic Realms and Regions of the Mammalia

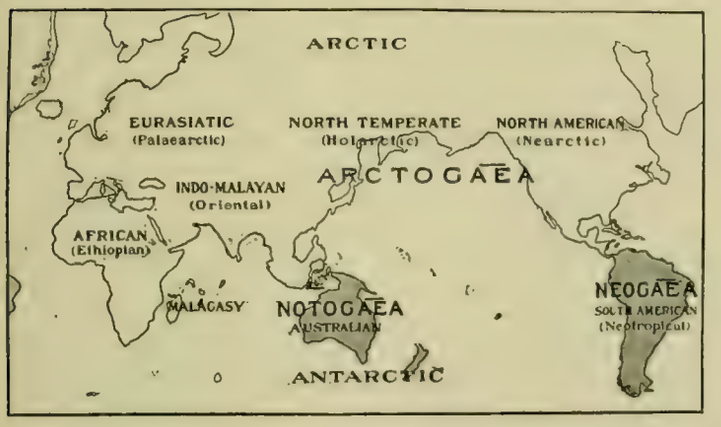


Fig. 9. Division of the world into three Realms (Huxley) and eight main Geographical Regions. The continental platform is raised to the 200-meter line showing the main Tertiary land connections. After Osborn, 1900.187, Fig. I; compare Osborn, 1900.182, Chart II.

Fig. 10. Orders of mammals as placed by Osborn in 1900 in their hypothetical chief centers of adaptive radiation during the Tertiary Period. The Proboscidea are placed very near the point of actual discovery in 1901 of their Fayûm ancestors. After Osborn, 1900.187, Fig. III; compare Osborn, 1900.182, Chart IV.

As regards the Proboscidea and Hyracoidea, the above geographic charts of 1900 were confirmed by Charles W. Andrews in 1901. As regards central Eurasia as the chief center of radiation of fourteen orders of mammals, the present Central Asiatic Expeditions of the American Museum are strongly confirmatory. As regards the Edentata, Litopterna, Toxodontia, and Typotheria, South America remains the chief center. As regards the Sirenia and Cetacea, it now appears probable that they also originated on the African continental shorelines.

This African or Ethiopian center theory of 1899–1900 was destined to enjoy almost immediate confirmation through the discovery in 1901 of the previously unknown Upper Eocene–Oligocene land fauna of North Africa. This Fayûm region had yielded between 1879–1885 a promising Eocene marine fauna and a Miocene land fauna containing one species of proboscidean (found to the north in Moghara, after 1898) related to *Trilophodon angustidens*.

1. ANDREWS CONFIRMS THE AFRICAN ORIGIN OF THE PROBOSCIDEA, SIRENIA, AND HYRACOIDEA

In April, 1901, Charles William Andrews of the British Museum had an opportunity of accompanying Hugh Beadnell, the geologist, into the Fayûm district. Here a marine (Zeuglodont) fauna had previously been found, and on this occasion a considerable number of vertebrate remains, including portions of skeletons of the proboscidean *Mœritherium* and of the sirenian *Eosiren*, were collected from beds of Upper Eocene age; the discovery of fluvio-marine beds of Lower Oligocene age resulted in the finding by Andrews of the first traces of the animal named *Palæomastodon*. *Mœritherium* was the *first Eocene proboscidean* to be discovered in any part of the world, and the type of the second genus, named *Palæomastodon beadnelli*, proves to be a possible ancestor[1] of the classic *Mastodon* of Cuvier. The expeditions of Beadnell (1901–1904), of Andrews (1901-1903), and collections now preserved in the British Museum and the Geological Museum of Cairo, form the subject of a series of papers by Andrews, culminating in his great Memoir of 1906, entitled, "A Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt. Based on the Collection of the Egyptian Government in the Geological Museum, Cairo, and on the Collection in the British Museum (Natural History), London."

After discussing the principal characters of the vertebrate fauna, Andrews (1906) presents the following conclusions regarding the homeland of the Proboscidea and the early history of these hitherto unknown mammals:

> [Andrews, 1906, p. xv] Although *Arsinoitherium* is certainly the most extraordinary of the Ungulates found in these beds, nevertheless the remains of the primitive members of the Proboscidea are perhaps of greater scientific interest, because they help to fill, at least to a large extent, one of the most obvious gaps in our knowledge of the extinct Mammalia. Previous to their discovery the earliest Proboscideans known were from the Lower Miocene (Burdigalien) of Europe and Northern Africa, and although many earlier deposits rich in mammalian remains were known in various parts of the world, in none of them was any trace of Proboscidea found, so that their appearance in Europe at the beginning of the Miocene period must be the result of their immigration from other regions. The probability that Africa would be found to be the original home of these animals was pointed out by several writers, notably by Osborn, Stehlin, and Tullberg. The first of these [Osborn, 1900.182, also 1900.187] suggested that probably not only the Proboscidea but also the 'Hyracoidea, certain Edentates, the Antelopes, the Giraffes, the Hippopotami, the most specialized Ruminants, and among the Rodents the Anomalures, the Dormice, and Jerboas, among Monkeys the Baboons,' and, as his map [Fig. 10] suggests, the Sirenia also, originated in this region. Osborn also put forward the theory that a succession of migrations from Africa to Europe occurred, notably at the end of the Eocene, at the beginning of the Miocene, and again in the earliest Pliocene. It was in the early Miocene migration that the Proboscidea passed out of Africa for the first time so far as known. Stehlin [1900], who also emphasized the importance of Africa as a probable centre of mammalian evolution, expressed much the same views. Tullberg [1899] likewise regarded Africa as a centre of mammalian radiation, and pointed to *Hystrix* (or the whole of the Hystricognathi), the Simiæ (Anthropoidea), and the Proboscidea as having probably migrated thence in the early Miocene. It is therefore very satisfactory that the earliest traces of land-mammals from the Eocene of Africa include remains of primitive Proboscidea, as well as early forms of Hyracoidea, Sirenia, and perhaps some of the other groups.
>
> The earliest-known Proboscidean is *Mœritherium*, which occurs first in the Qasr-el-Sagha beds (Middle Eocene) and persisted till the Upper Eocene, its remains having been found in the Fluvio-marine series. This animal was about the size of a Tapir, which it must have greatly resembled in general appearance. . . . [p. xvii] The limbs are unfortunately not well known. The humerus differs considerably from that of the later Proboscidea, but some of the smaller species of *Palæomastodon* (see text-fig. 56) from the Upper Eocene seem to supply intermediate forms: probably the difference arises from the fact that *Mœritherium* was a more or less amphibious type, while the later Elephants became fitted for progression on firm ground. The femur approximates very nearly to the form found in the later Proboscideans. As already mentioned, *Mœritherium* was probably an amphibious, shore, or swamp living animal, and it was no doubt owing to the continuation of the conditions favourable to its mode of life that it persisted into the Upper Eocene period. . . .
>
> The largest species of *Palæomastodon* (*P. beadnelli*) must have been about the size of a half-grown Indian Elephant: in its general appearance it was Elephant-like, but differed in having a longer neck and the symphysial portion of the mandible prolonged beyond the skull (see text-fig. 48, p. 131) and covered only with the fleshy snout. Probably it could reach the ground with its lower incisors, and the end of the snout may already have been prehensile. . . . [p. xviii] In general appear-

[1](Osborn, 1935) This proves to be an error on the part of both Matsumoto and Osborn; *Palæomastodon* is not an ancestor of *Mastodon*, *Zygolophodon*, or *Turicius* (cf. p. 43, Matsumoto's phylogeny). See PALÆOMASTODONTINÆ subfam. nov., page 65 and Appendix.

ance *Palæomastodon* must have resembled a small rather long-necked Elephant, the most notable difference being that the trunk, instead of being freely flexible, was supported by, and formed the upper covering of, the elongated mandibular symphysis; its extremity, however, may have been free and to some degree prehensile.

The further history of this group can only be briefly summarised here (see Phil. Trans. 196B, 1903, p. 99). The next form, *Tetrabelodon angustidens* from the European Lower Miocene, has the symphysis still more elongated and the narial opening shifted further back. At the same time the molars, or at least the posterior ones, are greatly increased in size and possess more transverse ridges. . . . [p. xix] This animal attained the size of a moderately large Indian Elephant, and except for the inflexibility of the mandible-supported trunk must have been very similar in appearance. In the later Miocene the mandibular symphysis shortened, leaving the trunk mobile and unsupported, as we now know it; at the same time traces of its original elongated condition are retained in the occurrence of deciduous lower incisors in some species of *Mastodon* and in the peculiar sharp process of the symphysis in the Elephants. . . . The above is, of course, only a general summary of the succession of forms which lead up to the modern Elephants, and no doubt there have been many checks and side-branches leading only to extinction in the course of the vast period that has elapsed since *Mœritherium* existed. . . . [p. xxi] The question of the origin of the Sirenia is of great interest, and there seems to be a considerable amount of evidence in favour of the view first put forward by de Blainville, that they are intimately related to the Proboscidea. In the first place, the occurrence of the most primitive Sirenians with which we are acquainted in the same region as the most generalised Proboscidean *Mœritherium* is in favour of such a view, and this is further supported by the similarity of the brain-structure and, to some extent, of the pelvis in the earliest-known members of the two groups (see pp. 202 & 214). . . . [p. xxvii] Another consideration which adds to the importance of Africa as a centre of mammalian evolution has been pointed out by Stromer [1903], namely, that part of it at least has probably never been submerged since the Palæozoic period, and formed a portion of a vast Permo-Triassic land-area inhabited by a great variety of mammal-like Theriodont reptiles from which the Mammalia may have actually arisen. This being the case, it is not only the Tertiary, but also the Secondary, deposits of this region that may be expected to yield most important data for the history of the Mammalia.

MAP OF THE REGION EXPLORED BY THE AMERICAN MUSEUM EXPEDITION OF 1907
Route of the Expedition indicated by dotted lines and arrows

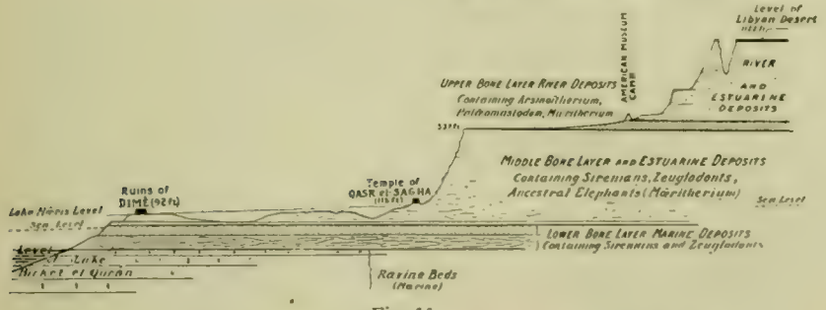


Fig. 11

Fig. 11. Section showing the lowering levels of the ancient Lake Mœris, of the brackish Birket-el-Qurun, and of the sea, with the (1) lower marine *Zeuglodon* beds (Middle Eocene), (2) middle Qasr-el-Sagha *Mœritherium* beds (Upper Eocene), (3) upper Fluvio-marine *Palæomastodon* beds (Lower Oligocene). After Osborn, 1907.302, Century Magazine, p. 827.

Fig. 12. The horizontal lines indicate the fertile lands of the Nile and of the Fayûm. The Fayûm area formerly covered by Lake Mœris is now reduced to the brackish Birket-el-Qurun. The oblique dots north of Birket-el-Qurun indicate the area of the marine Qasr-el-Sagha beds. On the bluffs to the northwest are the Fluvio-marine beds, on which was placed the American Museum camp. After Osborn, 1907.302, Century Magazine, p. 826.

Fig. 12

Andrews thus adopted the Osborn-Stehlin-Tullberg theory that Africa was an important center of adaptive radiation of the Mammalia and called attention (p. xxv) to the fact that "the species known must be a mere fraction of the faunas inhabiting the Ethiopian region during the Middle and Upper Eocene periods"; he maintained that Osborn, Stehlin, and Tullberg were fully justified "in their assumption that the Ethiopian continent in early Tertiary (and perhaps pre-Tertiary) times was a very important centre of mammalian evolution."

Finally, the Deinotheres, although first discovered in Europe and Asia, have been found in recent years in deposits of Lower Miocene age in central (*Deinotherium hobleyi*) and northern (*D. cuvieri*) Africa, as fully described in Chapter IV. Consequently early members of the Mœritheres, of the Deinotheres, of the true mastodonts, and of the bunomastodonts have been discovered in deposits of Upper Eocene to Lower Miocene age in the comparatively unexplored continent of Africa. In the Pleistocene of Africa occurs *Deinotherium hopwoodi* sp.nov.

2. AMERICAN MUSEUM FAYÛM EXPEDITION OF 1907. INTERPRETATION AND DISCOVERY BEARING ON THE PHYLOGENY OF THE FAYÛM PROBOSCIDEA

The general inference drawn from Andrews' memoir and popular articles and restorations was that the genera *Mœritherium* and *Palæomastodon* constituted the first and second links in a chain of descent which led up to the classic *Mastodon angustidens* of Europe, thus:

Mastodon (*Tetrabelodon* [= *Trilophodon*]) *angustidens* of the Miocene of France.
Palæomastodon, including a variety of species, Upper Eocene to Oligocene of Egypt.
Mœritherium, including at least two species, Middle and Upper Eocene of Egypt.

Second Restoration of Mœritherium and Phiomia by Osborn and Christman, 1908
Compare front views (Figs. 19 and 20)

Fig. 13. Side view of the head of *Mœritherium* with the eye and ear in position, the form and position of the nostrils being somewhat conjectural. Observe the elongated cranial region and abbreviated facial region; also the direct opposition of the upper and lower incisor teeth. Modeled by Erwin Christman, under the direction of Osborn in 1908. After Osborn, 1909.332, p. 140, fig. 2.

Fig. 14. Side view of the head of *Phiomia wintoni*, as modeled in 1908 by Erwin Christman, under the direction of Osborn. Observe the abbreviated cranial region, the elongated facial region, the upper tusks passing on the outer side of the lower tusks. Originally described as *Palæomastodon*. After Osborn, 1909.332, p. 139, fig. 1.

This *monophyletic* interpretation of Andrews' conclusions was due rather to his broad inferences than to an examination of his actual descriptions in which the divergent adaptations to habit and to habitat, which would militate against any monophyletic theory, were clearly pointed out. But despite Andrews' admirable work, the opinion widely prevailed up to the year 1909 that *Mœritherium* gave rise to *Palæomastodon* and that *Palæomastodon* gave rise to *Mastodon angustidens*.

The first to combat this monophyletic interpretation was Osborn who led an expedition into the Fayûm region early in the year 1907, immediately after the publication of Andrews' great memoir, assisted by Walter Granger and George Olsen. A preliminary study of the extensive collections of *Mœritherium*, *Palæomastodon*, and *Phiomia*, followed by comparison and restoration for purposes of exhibition in the American Museum, was entirely against the theory that *Mœritherium* gave rise to *Palæomastodon;* in fact, it was in this process of restoration, as shown in the accompanying figures (Figs. 13, 14), that profound divergences between *Palæomastodon* (=*Phiomia*) and *Mœritherium* were brought out. This led to the publication in "Nature," July 29, 1909, of Osborn's paper, entitled, "The Feeding Habits of Mœritherium and Palæomastodon." As will be fully set forth in Chapter XXI on "Affinities, Migrations, and Phylogeny of the Proboscidea," differences in feeding habits give us the key to divergence, divergence gives us the key to phylogenetic separation and succession, and phylogenetic separation gives us the key to classification.

Recent studies by Gregory (1910–1920), Matsumoto (1923), and Simpson (1932) point towards the existence in Upper Cretaceous and Lower Eocene time in Africa of a common ancestral form of mammal which by adaptive radiation through ground-loving, shore-loving, and water-loving habits, may have given rise to the Sirenians (Fig. 15), the Mœritheres, and the Proboscideans. Widely different and profoundly divergent as the two great orders of Sirenians and Proboscideans are today, they still exhibit certain common characters in their internal anatomy, certain common characters in their cranial and labial structure, as well as one unique character in their grinding teeth, namely, *trilophodonty* or the evolution of three crests on the superior and inferior molars. Recent studies by Simpson (1932) show that the Pre-Pleistocene forms of America are Dugongs rather than Manatees.

Restoration of the Eocene and Recent Sirenians (Eosiren and Trichechus)

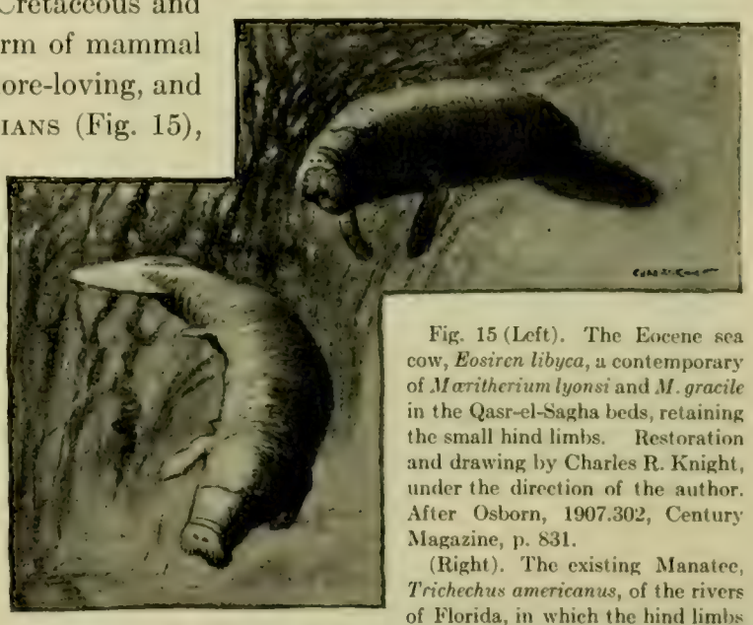


Fig. 15 (Left). The Eocene sea cow, *Eosiren libyca*, a contemporary of *Mœritherium lyonsi* and *M. gracile* in the Qasr-el-Sagha beds, retaining the small hind limbs. Restoration and drawing by Charles R. Knight, under the direction of the author. After Osborn, 1907.302, Century Magazine, p. 831.

(Right). The existing Manatee, *Trichechus americanus*, of the rivers of Florida, in which the hind limbs have entirely disappeared. Restoration and drawing by Charles R. Knight, under the direction of the author. After Osborn, 1907.302, Century Magazine, p. 831.

3. RELATIONS OF MŒRITHERIUM, PALÆOMASTODON, AND PHIOMIA TO EACH OTHER AND TO OTHER MAMMALS

It appears that Osborn in 1909 went too far in separating *Mœritherium* from direct relationship to the Proboscidea; he erred in the opposite direction, as shown in the following quotation (Osborn, 1909.332, p. 139): "The conclusion is that Mœritherium was a confirmed and continual river-living animal, feeding mainly under water and on the banks, more specialised for aquatic life than the hippopotami, as indicated by its feeble pelvis, but less specialised than the Sirenians. It would not be far from the truth to say, from our present knowledge of the animal, that Mœritherium is an offshoot of the Proboscideo-Sirenian stock, with *slightly* nearer kinship to the elephants than to the Sirenians." This conclusion should now certainly be greatly modified, because *Mœritherium* proves to be of much nearer kinship to the Proboscidea than to the Sirenia; it is in fact one of the primary stocks of the Proboscidea.

To Osborn's extreme view Andrews replied in 1909, p. 305 ("The Systematic Position of Mœritherium," Nature, LXXXI, p. 305): "On the whole, it seems that the weight of evidence is in favour of regarding Mœritherium as a proboscidean, though perhaps not on the direct line of ancestry of Palæomastodon, and retaining some characters of the original Proboscideo-Sirenian stock." Schlosser (1911) considered it doubtful whether *Mœritherium* stands in the direct line of ancestry of *Palæomastodon*. Gregory ("The Orders of Mammals," 1910, p. 368) concluded: "The genus [*Mœritherium*] represents a very primitive offshoot from the Proboscideo-

The Osborn-Knight early Restorations, in the year 1907, of Mœritherium (Upper Eocene), Phiomia (Lower Oligocene), and Parelephas (Upper Pleistocene). Compare more recent (1932, 1933) Restorations in this Memoir.

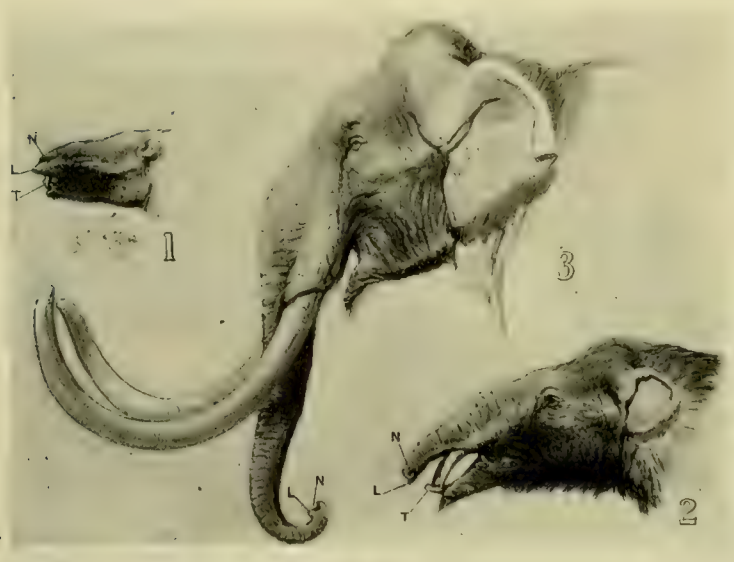


Fig. 16.

Fig. 16. (Left) Evolution of the head, proboscis, nostrils, and tusks in: (1) *Mœritherium*, (2) *Phiomia wintoni*, (3) *Parelephas jeffersonii*, as restored by Charles R. Knight in 1907, under the direction of the author. After Osborn, 1907.302, Century Magazine, p. 833.

(Right) Comparative restorations to scale of: (1) *Mœritherium andrewsi*, (2) *Phiomia osborni*, (3) *Parelephas jeffersonii*. Drawn by Charles R. Knight in 1907, under the direction of the author. After Osborn, 1907.302, Century Magazine, p. 834. Scale approximately one-fiftieth natural size.

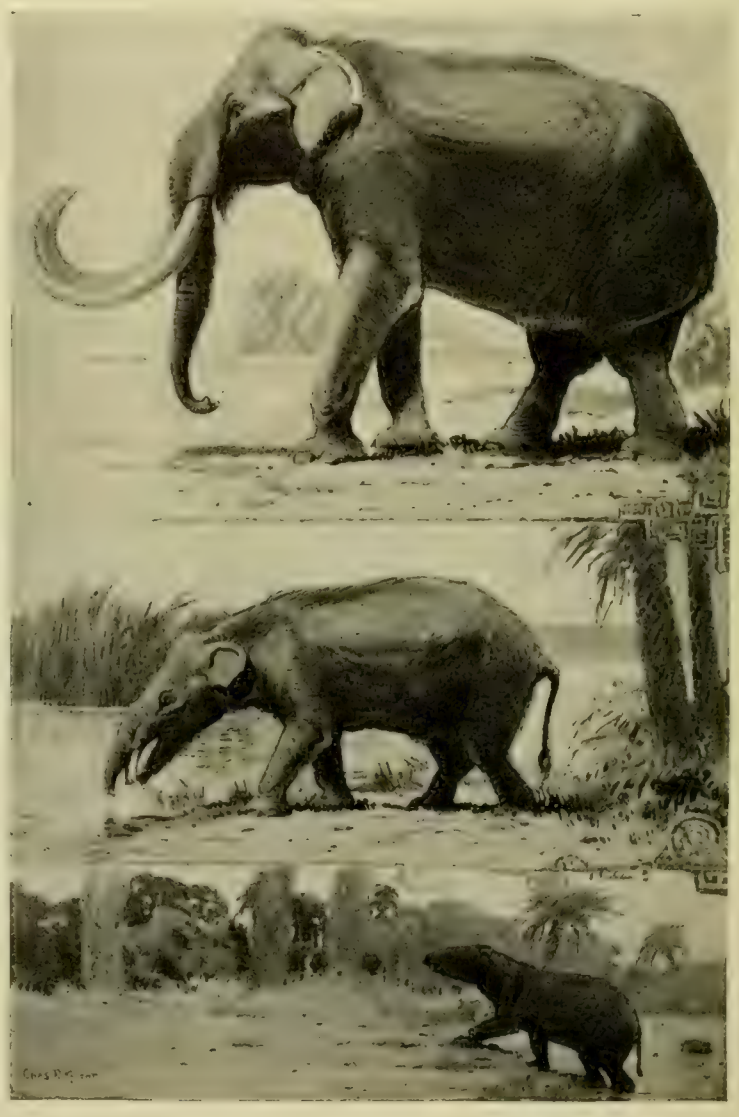


Fig. 16

Sirenian stock. Its dentition and certain other characters indicate a nearer alliance with the Proboscidea than with the Sirenia, but it is far more primitive than any other known representative of either order." More recently, Gregory (1920, p. 180) in his exhaustive study on the lacrymal bone of the vertebrates declares: "The orbital region [of *Mœritherium*] is much more primitive than that of other Proboscidea, and suggests the sirenian type. . . . [p. 245] The Sirenia, although very highly specialized for aquatic life, show special resemblances with *Mœritherium* in the skull (including the orbital region) and dentition, and are generally regarded as a derivative of the proboscidean stem."

4. MATSUMOTO'S COMPLETE SEPARATION OF MŒRITHERIUM, PALÆOMASTODON, AND PHIOMIA

Matsumoto (1922, 1923, 1924) was the first to make a profound examination of the rich collections of *Mœritherium*, *Palæomastodon*, and *Phiomia* in the American Museum, in comparison with the type and referred specimens in the British and Cairo Museums. Aided by the new evidence presented in this rich American Museum material, he deserves the chief credit: (1) Of clearly distinguishing the genus *Palæomastodon* from the genus *Phiomia*, (2) of clearly defining and distinguishing three species of *Phiomia* and three species of *Palæomastodon*, (3) of distinguishing species of *Mœritherium*, (4) of closely comparing these three genera with each other and with representatives of the great orders Sirenia and Hyracoidea which occur in the same deposits.

In the present Memoir Osborn entirely confirms Matsumoto's principal systematic conclusions. Matsumoto's separation of the genera *Palæomastodon* and *Phiomia* is a confirmation of one of Andrews' observations, namely (Andrews, 1905, p. 562): "The species of *Palæomastodon* fall into two sections, in one of which the posterior end of the symphysis of the mandible is situated considerably in front of the level of the anterior premolar, while in the other it is only very little in front of that point. The first group, moreover, is distinguished by the comparative simplicity of the molars, in which the accessory cusps are scarcely at all developed, and by the small size of the talon of the last lower molar; into this subdivision the original species, *P. beadnelli*, falls, together with a much smaller form for which the name *P. parvus* is now proposed. The type-specimen of this new species is the right ramus of the mandible, with the premolars and molars *in situ*, though somewhat crushed."

The profound structural and adaptive differences between these three genera of proboscideans, *Mœritherium*, *Palæomastodon* (*sensu strictu*), and *Phiomia*, will be fully set forth in the systematic section below. A significant feature of this separation is that it tends to greatly strengthen the theory that *Africa was the original homeland of the order Proboscidea* in which they widely diverged from each other during Lower and Middle Eocene times, so that as we find them in Upper Eocene time they are distinctly *polyphyletic*. This gives a death blow to all the monophyletic inferences based on Andrews' earlier writings.

The relations of these three great phyla to each other are set forth in the section on phylogeny and classification (Vol. II) and in the present chapter. The relations of these three phyla of Proboscidea to the Sirenia and the Hyracoidea respectively are discussed in detail in Matsumoto's paper of 1923, entitled, "A Contribution to the Knowledge of *Mœritherium*," in which he takes up with great fullness the following topics:

A.—Characters Possibly Indicating Aquatic Adaptation (p. 102). B.—Characters Indicating Terrestrial and Non-aquatic Adaptation (p. 104). C.—Characters in Common with the Hyracoids (p. 105). D.—Characters Distinctive from the Hyracoids (p. 109). E.—Characters in Common with the Sirenians (p. 111). F.—Characters Distinctive from the Sirenians (p. 112). G.—Proboscidean Characters (p. 114). H.—Peculiar and Pre-Palæomastodont Characters (p. 117). I.—Natural Position of Mœritherium (p. 121). J.—Evolutionary Tendencies in the Earlier Proboscideans (p. 121). K.—Phylogenetic Relations Among the Hyracoids, Earlier Proboscideans, and Sirenians (p. 123).

Phylogenetic Relations of Proboscideans to Sirenians and Hyracoids.—Matsumoto's conclusions may be paraphrased as follows: (1) That the proboscideans and sirenians were very closely related to each other in their earlier stages of evolution has been maintained by many eminent authors, such as De Blainville, Andrews, Osborn, Gregory, etc.; (2) it is very obvious that in their earlier stages they resembled each other in certain respects, but

the phylogenetic relationship between the Proboscidea and Sirenia is somewhat less close than is considered by those authors (e. g., Osborn) who emphasize chiefly the resemblances between *Mœritherium* and the earlier sirenians; (3) certain similarities between *Mœritherium* and the earlier sirenians are probably due to their original phylogenetic relationship, other resemblances are attributable to convergence, i. e., similarity of habits, still other resemblances are primitive characters common to all three groups of early sirenians, early proboscideans, and early hyracoids; (4) as to progressive development, it is obvious that the differences observed between the sirenian series of *Prorastomus*, *Eotherium*, *Prosiren*, *Eosiren*, *Miosiren*, *Halitherium*, *Halicore*, etc. and the progressive development of the proboscideans *Mœritherium*, *Palæomastodon*, *Trilophodon*, and *Megabelodon* are very great; (5) doubtless no known sirenian can be looked upon as an ancestral type of *Mœritherium*, nor can *Mœritherium* be looked upon as an ancestral type of any known sirenian; (6) consequently both the sirenians and the proboscideans may have descended from unknown ancestors that stand closer to each other than they do to the Hyracoidea stock. Detailed examination and comparison of thirty-four characters in sirenians, hyracoids, and early proboscideans led Matsumoto (1923, p. 114) to the following somewhat conflicting conclusion: "Among these thirty-four characters examined, thirteen, *viz.* (2), (9), (10), (12), (13), (15), (16), (17), (18), (19), (21), (25), and (26), are common to both the hyracoids and proboscideans in contrast to the [earlier or later] sirenians; ten, *viz.* (4), (8), (11), (14), (20), (22), (27), (28), (29), and (30), are characteristic of the proboscideans in contrast to both the hyracoids and earlier or later sirenians; three, *viz.* (5), (7) and (23), are characteristic of the proboscideans in contrast, at least, to the earlier or later sirenians; three, *viz.* (32), (33), and (34), are characters vaguely distinctive of this genus from the earlier or later sirenians; three, *viz.* (9), (13), and (23) [these characters are referred to in duplicate], are characters of some of the terrestrial mammals in contrast to the aquatic ungulates; and one, *viz.* (31), is characteristic of this genus in contrast to all the hyracoids, sirenians, and other proboscideans or earlier forms of these groups. It may easily be recognized that *Mœritherium* has many characters common to both the hyracoids and proboscideans in contrast to the earlier or later sirenians, and many characteristics of the proboscideans in contrast to both the hyracoids and later sirenians or earlier sirenians."

Osborn, 1924: In our opinion *Mœritherium*, a true proboscidean of primitive type, stands much closer to the stem forms of the Sirenia than to the stem forms of the Hyracoidea; for the degree of this closeness we must wait for fuller evidence from Middle and Lower Eocene deposits in Africa.

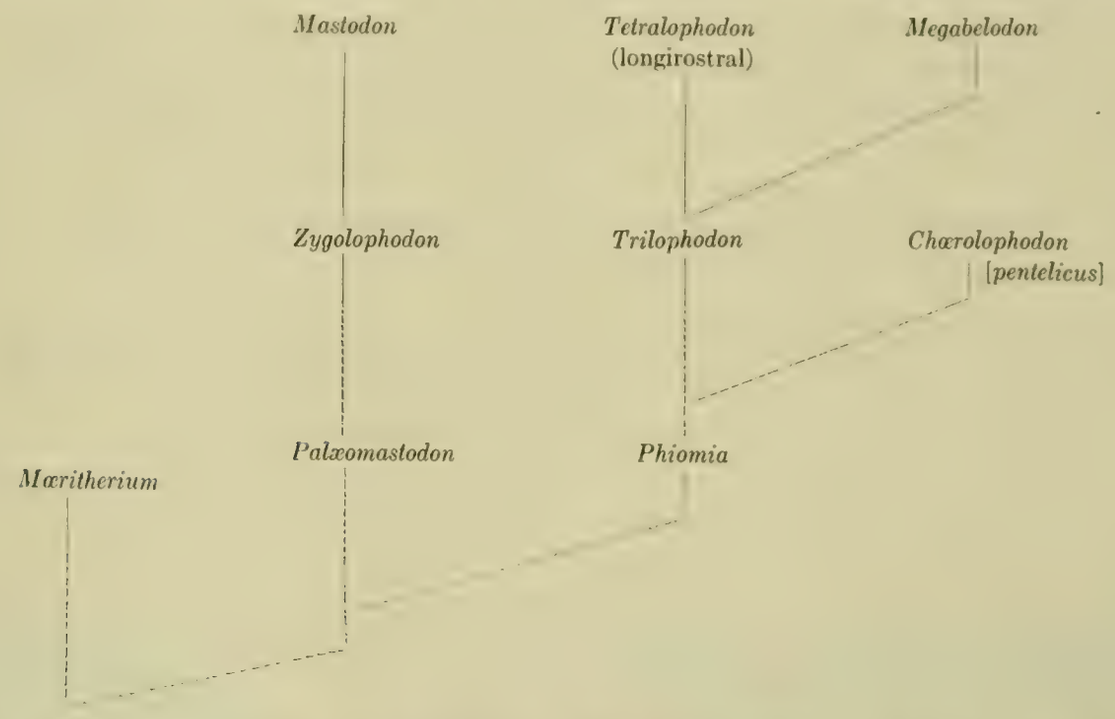
Proboscidean Characters of Mœritherium (Matsumoto, 1923).—Having dismissed the resemblances to the Sirenia and Hyracoidea as principally due to inheritance from primitive mammalian characters in general and also to convergence, Matsumoto applies a thirty-five character test and sets forth a very strong argument for the dominant relationship of *Mœritherium* to the Proboscidea and especially for its *peculiar and pre-palæomastodont characters*. After comparing and contrasting *Mœritherium* with *Palæomastodon*, we may paraphrase his conclusion as follows (p. 120): (1) In all the twenty-three characters examined, *Mœritherium* is structurally a *pre-palæomastodont* type so far as we admit the conception that *Palæomastodon*, *Trilophodon*, and *Megabelodon* form together a fair series of evolutionary stages; (2) it is, of course, beyond doubt that the structural gap between *Mœritherium* and *Palæomastodon* is fairly great, yet the fact should not be neglected that *Mœritherium* stands structurally before *Palæomastodon* in the majority of its characters, that is, as a more primitive form; (3) consequently a presumed ancestral type of *Palæomastodon* should resemble *Mœritherium* in many characters.

Osborn, 1924: In our opinion Andrews and Matsumoto have positively established the proboscidean relationship of *Mœritherium*. Osborn differs from Andrews and Matsumoto in placing *Mœritherium* in an entirely separate line of descent, of superfamily rank known as Mœritherioidea, distinguished by direct opposition of the upper and lower incisor teeth, as in rodents, by many aquatic adaptations in the skull, by profound differences in skull

proportion, and probably by an amphibious mode of life approaching that of the hippopotami; in contrast to the purely terrestrial life of the *Palæomastodon* and *Phiomia* phyla. As to the amphibious habits of *Mæritherium*, Osborn and Matsumoto substantially agree.

Palæomastodon Ancestral to the True Mastodon (Matsumoto, 1924).—In Matsumoto's succeeding paper (1924.1), "A Revision of Palæomastodon," etc., he concludes by completely separating *Mæritherium* and placing it in an independent line, as shown in the accompanying diagram (*op. cit.*, p. 58):

In my opinion, the phylogenetic relationship of the genera just referred to, can be diagrammatically shown as follows:



In discussing the phylogeny of the earlier Proboscidea, Matsumoto (1924.1, pp. 55–57) makes a final comparison between the skull and dentition of *Mæritherium*, *Palæomastodon*, and *Phiomia;* he rightly places *Mæritherium* in a side-line of its own, but wrongly determines that the true *Palæomastodon* points towards *Zygolophodon* and the true *Mastodon* of the *Mastodon americanus* type for the following reasons. (1) The skull of *Palæomastodon* is not clearly known; judging from the shape of the palate it is probably shorter skulled than *Phiomia* which is distinctly long skulled; the skull of *Zygolophodon* of the European Miocene is not yet clearly known; the true *Mastodon* is distinctly short skulled. (2) The palate of the true *Palæomastodon* is very wide in proportion to the length of the cheek teeth, while that of *Phiomia* is rather narrow in the same proportion; the palate of the true *Mastodon* is very wide. (3) The mandibular symphysis of *Palæomastodon* appears to be rather short, while that of *Phiomia* is very long; the symphysis of the true *Mastodon* is short. (4) The largest and most conspicuous of the anterior mental foramina lies just below the first cheek tooth, P_3; in the true *Mastodon* also the largest and most conspicuous of these foramina lies just below the anterior cheek tooth; in many short-jawed mastodonts and elephants the largest and most conspicuous of the anterior mental foramina lies just below the anterior cheek tooth also; the position of this foramen may be correlated with the development of the relatively short symphyseal region and the relatively small lower tusks, in contrast with the long symphyseal region and large lower tusks in the *Phiomia-Trilophodon* series. (5) The cheek teeth of *Palæomastodon* are proportionately shorter and wider than those of *Phiomia;* the cheek teeth of *Zygolophodon* and *Mastodon* are also proportionately shorter and wider than those of *Trilophodon*.

(6) The cheek teeth of *Palæomastodon* show a lower ridge formula than those of *Phiomia;* the potentiality of getting a higher ridge formula was lower in the *Zygolophodon-Mastodon* phylum than in the *Phiomia-Trilophodon* phylum. (7) The cheek teeth of *Palæomastodon* are bunolophodont attaining a typically lophodont character when moderately worn, while those of *Phiomia* are typically bunodont; the cheek teeth of *Zygolophodon* and *Mastodon* are lophodont, while those of *Phiomia* and *Trilophodon* are bunodont. (8) In the cheek teeth of *Mœritherium, Palæomastodon, Zygolophodon,* and *Mastodon* no trefoil pattern of cusps is developed, while in the *Phiomia-Trilophodon-Tetralophodon* phylum the trefoil pattern of cusps is well developed. (9) In the cheek teeth of *Mœritherium, Palæomastodon, Zygolophodon,* and *Mastodon* the crests are not very thick anteroposteriorly, the valleys are widely open and even the walls and bottoms of the valleys are worn, while in those of *Phiomia, Trilophodon,* and *Tetralophodon* the crests are very thick anteroposteriorly, the valleys are not so widely open, the worn surfaces are almost even. In the cheek teeth of *Mœritherium, Palæomastodon, Zygolophodon,* and *Mastodon* the surface of the enamel is rather smooth, while in those of *Phiomia, Trilophodon,* and *Tetralophodon* the same is very rough.

For all these reasons, Matsumoto continues, *Palæomastodon* appears nearly to correspond to a theoretical ancestral type of the *Zygolophodon-Mastodon* phylum; *Palæomastodon* appears to correspond to the beginning of a very great phylum, namely, the *Zygolophodon-Mastodon* phylum.

Matsumoto thus announces a very important phylogenetic discovery, i. e., that *Palæomastodon* stands near the ancestry of the true Mastodontidæ. This discovery was immediately approved by Osborn, before the publication by Matsumoto of his complete results, with the following comments (see Matsumoto, 1922, p. 6, "Note by Henry Fairfield Osborn, August, 1922"): "The significance of the above revision [Matsumoto's] is that the true *Palæomastodon beadnelli* has bilophodont intermediate molars and a relatively broad skull; it is a rare animal both in the British Museum and American Museum collections; according to Andrews ([letter], 1922) the genotype (*Palæomastodon beadnelli*) was found at the very base of the Fluvio-marine Beds, Lower Oligocene, 50 or 100 feet below the *Phiomia* level. . . . Associated with the type is a very large femur and humerus." *Palæomastodon* is a relatively short-jawed animal, with bilophodont intermediate molars, whereas *Phiomia* is a very long-jawed animal with trilophodont intermediate molars.

Matsumoto's theory is now (1935) rendered improbable by Osborn's closer studies in the present Memoir of the limited material of the true *Palæomastodon* from the Fayûm (see footnote on p. 36 above).

Phiomia Ancestral to the True Trilophodon.[1]—From the first Andrews recognized the kinship of *Phiomia* to *Trilophodon angustidens;* Matsumoto goes further and proves that *Phiomia* is directly ancestral to what he terms the *Trilophodon-Tetralophodon-Megabelodon* phylum, whereas it has nothing to do with the ancestry of the *Zygolophodon-Mastodon* phylum. The kinship of *Phiomia* to *Trilophodon* is clearly indicated in the following characters: (1) *Phiomia, Trilophodon,* and *Megabelodon* are distinctly long skulled; (2) the palate of *Phiomia* is rather narrow in proportion to the length of the cheek teeth, the palates of *Trilophodon* and *Megabelodon* are also distinctly narrow; (3) the mandibular symphysis of *Phiomia* is very long, while the mandibular symphysis of *Trilophodon* and of *Megabelodon* is extremely long; (4) the anterior mental foramen in *Phiomia* lies on either side of the symphyseal region far anterior to the front cheek tooth, P_3, and to the posterior end of the symphysis, in both *Trilophodon* and *Megabelodon* the position of the anterior mental foramen being quite similar to that observed in *Phiomia;* (5) the cheek teeth of *Phiomia* show a trilophodont ridge formula almost similar to that of *Trilophodon,* the potentiality of a multiple ridge formula is thus high in the *Phiomia-Trilophodon-Megabelodon* phylum, whereas it is low in the *Palæomastodon* phylum and still lower in the *Mœritherium* phylum; (6) the cheek teeth of *Phiomia* are typically bunodont, those of *Trilophodon, Tetralophodon,* and *Megabelodon* are also bunodont; (7) in *Phiomia,*

[1](Osborn, 1935) The three or four known species of *Phiomia* are now recognized as directly ancestral only to the shovel-tusker *Amebelodon* of Nebraska. See Plate v between pages 235 and 236.

Trilophodon, *Tetralophodon*, and *Megabelodon* the trefoil pattern of cusps is well developed; (8) the transverse crests in *Phiomia*, *Trilophodon*, *Tetralophodon*, and *Megabelodon* are very thick anteroposteriorly, the valleys are not so widely open, and the worn surfaces are almost even; (9) the surface of the enamel is relatively rough in *Phiomia*, *Trilophodon*, *Tetralophodon*, and *Megabelodon;* (10) the basal cingula are very rough and strong in *Phiomia*, *Trilophodon*, *Tetralophodon*, and *Megabelodon*, whereas they are rather feeble in *Palæomastodon* and *Mastodon* and more or less strong in *Mœritherium;* (11) thus *Phiomia* appears to correspond to the beginning of a very great phylum, namely, the *Trilophodon-Tetralophodon* phylum of the Old World.

Osborn, 1924: Quite independently of Matsumoto, Osborn had confirmed and extended Andrews' opinion as to the *Phiomia-Trilophodon* phylum, and as early as 1917 (Osborn, 1918.468) placed *Phiomia* (=*Palæomastodon*) in the true longirostral line which he termed the Longirostrinæ; but Matsumoto deserves the priority not only for clearly distinguishing *Palæomastodon* from *Phiomia*, but for suggesting that *Palæomastodon* was related to the subfamily which Osborn designates as Mastodontinæ.

5. AFRICA DEMONSTRATED AS THE HOMELAND OF THE THREE PRIMITIVE FAMILIES MŒRITHERIIDÆ, MASTODONTIDÆ, AND BUNOMASTODONTIDÆ

Thus Andrews, Osborn, and Matsumoto have successively prepared the way for a true understanding of the *three great and widely distinct phyla* of Proboscidea in northern Africa in Upper Eocene and Lower Oligocene times. As more fully pointed out in the phylogenetic classification of the forthcoming Volume II, the wide divergence of these phyla tends to confirm the theory that Africa was the homeland of the stem forms of all the Proboscidea, although it does not as yet finally demonstrate it.

Osborn's present classification of the thirteen species of the primitive North African Proboscidea is shown on page 65.

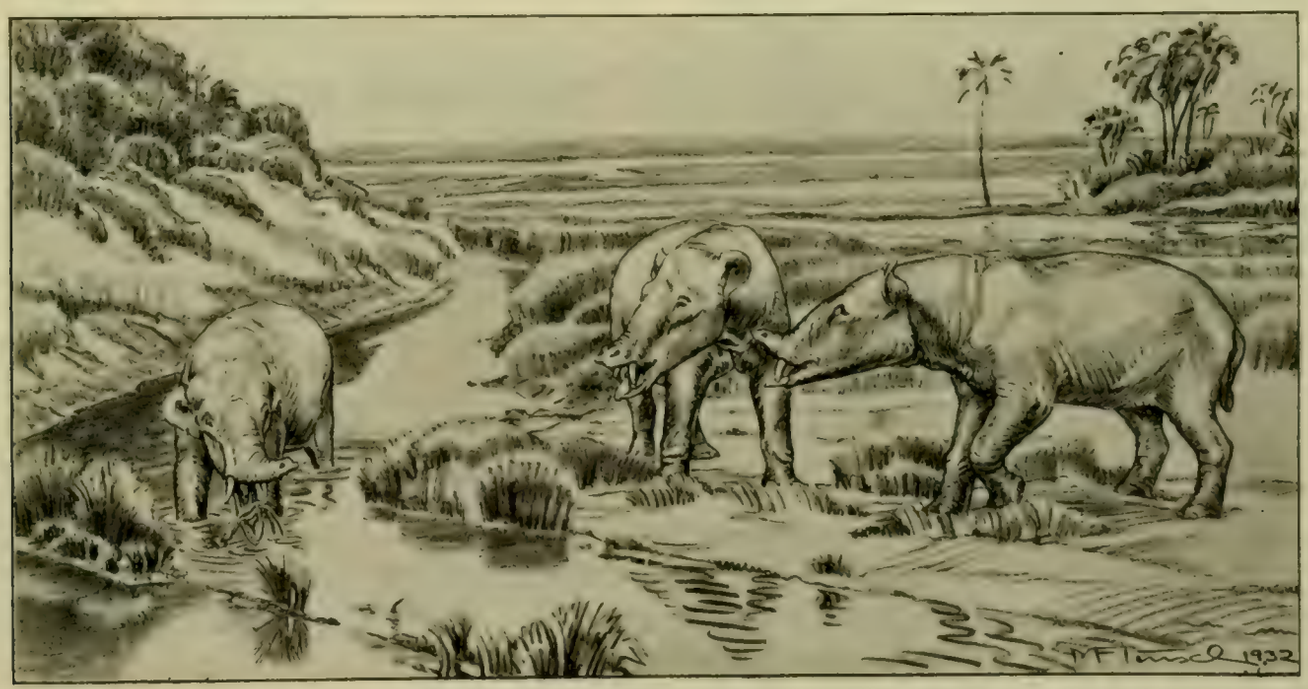


Fig. 17. Phiomia osborni, Primitive Lower Oligocene Shovel-Tusker of the Fayûm, Egypt
Restored (1932) by Margret Flinsch, under the Direction of Henry Fairfield Osborn
All figures one thirty-sixth natural size

Phiomia osborni frequented the flood-plain region of the Nile and the present restoration shows a group of these animals in their natural habitat in Lower Oligocene time. The three specimens are based on a single lower jaw, which Matsumoto in 1922 dedicated to the present author; their estimated shoulder height is 1345 mm. or 4 ft. 5 in.

III. PHYLOGENETIC RELATIONS AND CLASSIFICATION OF MŒRITHERIUM, PALÆOMASTODON, AND PHIOMIA

The systematic descriptions and the nomenclature of the Fayûm Proboscidea will be clearly reviewed below. Let us first examine their structure more closely with regard to adaptations to certain habits and modes of life and to progressive tendencies towards increasing perfection and specialization in adaptation. The Proboscidea follow the principle which we have clearly observed in many other ungulates, especially the families Brontotheriidæ, Rhinocerotidæ, and Equidæ, which the author has been studying and comparing for the past thirty-four years, namely, *a phylum having once started in a certain adaptive direction, if unchecked, will proceed to the extreme of adaptation.*

For example, elongation of the jaws, of the skull, and of the teeth begins in *Phiomia* and reaches an extreme in certain species of trilophodonts in which the progressive development is known as longirostral.

Text-fig. 40.

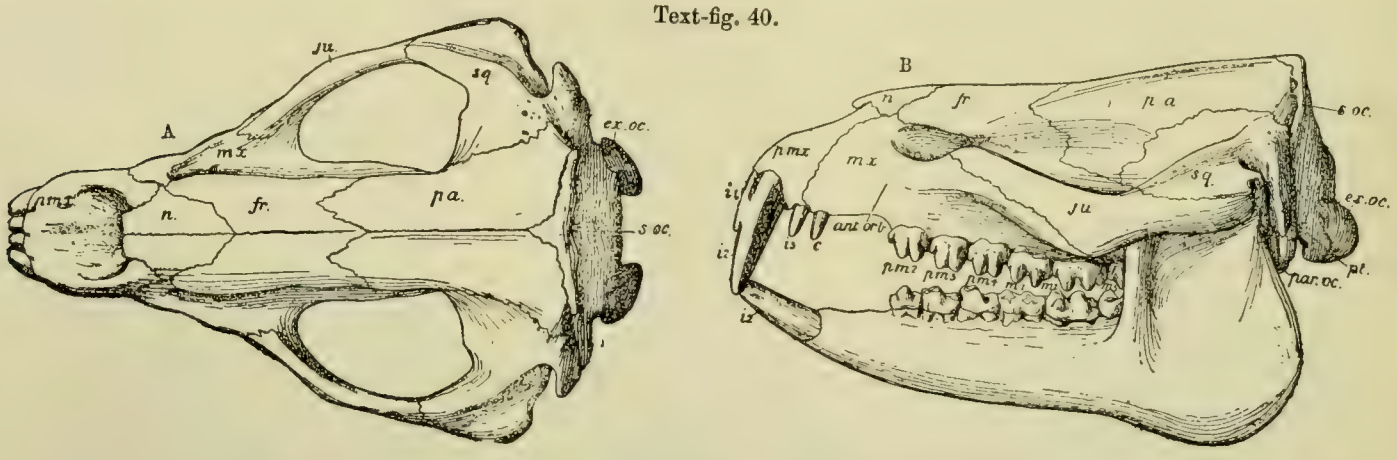


Fig. 18. First reconstruction by Charles W. Andrews of skull and mandible of *Mœritherium lyonsi*. A, from above; B, from left side. After Andrews, 1906, text figure 40. About one-fourth natural size.

The Osborn-Matsumoto reconstruction (Fig. 42) of the skull of *M. andrewsi-trigodon* differs widely in the relations of the upper and lower incisor teeth, I^2-I_2. These teeth are actually less tusklike and more gliriform than as restored by Andrews (Fig. 18).

1. PRINCIPLE OF ADAPTIVE RADIATION EXPRESSED IN THE PHYLOGENETIC CLASSIFICATION OF THE FAYÛM PROBOSCIDEA

Classification should be expressive of phylogeny as brought about through *adaptive radiation* into diverse habits and habitats which influence, *first*, the entire dental and cranial structure, *second*, the entire foot, limb, and body structure, *third*, the adaptation of dental, cranial, limb, and body structure to defense and offense, and, *fourth*, coadaptation and compensation through gain and loss of other organs.

The analysis of the feeding and locomotor habits is the basis of the phylogeny and therefore of the classification of the Proboscidea, from the first appearance of these animals in the Upper Eocene up to the surviving recent forms in Asia and Africa.

Résumé of Preceding Section.—Through the discoveries of Andrews (1901–1906) in the Eocene-Oligocene of the Fayûm of Egypt of three very distinct types, namely, of *Palæomastodon* (very rare), of *Mœritherium* (numerous), of *Phiomia* (very numerous), these three animals have become famous as the earliest known stages in the ancestry of the elephants. Since the wish is always father to the thought, and nothing was more eagerly sought for prior to 1901 than the primitive progenitors of the Proboscidea, it was altogether natural to place *Mœritherium* in or near the direct line of ancestry of *Elephas*, and consequently, with this idea, to provide *Mœritherium*, *Palæomastodon*, and *Phiomia* with a proboscis of less or greater length such as would befit more or less remote direct ancestors of the elephant.

As such direct ancestors these three animals have gone forth into the general literature, and have therefore taken an entirely false and unnatural position in popular treatises on phylogeny. Andrews tried to correct this error in his great Memoir of 1906, and Osborn (1909.332) in his article "The Feeding Habits of Mœritherium and Palæomastodon," followed by Matsumoto (1923), pointed out that since the dental and cranial structure of these three animals was profoundly different, it followed that the feeding habits were profoundly different and that they fed in three different habitats, consequently that their limb and body structure must have been different, finally, that none was ancestral to the other or to the genus *Elephas*. In brief, we were all so eager to welcome these animals into the order Proboscidea, that we too hastily assumed their ancestral position.

We shall see that *Mœritherium*, *Phiomia*, and *Palæomastodon* are widely separated both by habits and by structure from each other, as well as from the still to be discovered direct ancestors of the true elephants.

2. AMPHIBIOUS HABITS OF MŒRITHERIUM

The first more cautious note against the true-*Elephas* ancestry theory was sounded by Andrews in his Memoir of 1906 (1906, p. xvii) from which Osborn (1909.332, p. 139) made the following citation and comments:

> 'As already mentioned, Mœritherium was probably an amphibious, shore, or swamp living animal, and it was no doubt owing to the continuation of the conditions favourable to its mode of life that it persisted into the Upper Eocene period. In the meantime, however, either from this or some closely allied type, there had arisen another animal more adapted to terrestrial life and showing a great advance in the direction of the typical Proboscidea: to this creature the name Palæomastodon has been given.' Elsewhere (p. xxi) Dr. Andrews notes that Mœritherium favours the view, first put forward by de Blainville, of an original relationship between the Proboscidea and Sirenia. Later on in the same work (p. 119) the same author, in commenting on the similarity between the pelvis of Mœritherium and that of the Eocene sirenian Eotherium, observes:—'Then it may fairly be suggested that Mœritherium and Eotherium, both occurring in the same region (one the most primitive Proboscidean, the other occupying the same position with regard to the Sirenia), are, in fact, closely related, and had a common ancestor in early Tertiary times, probably in the Lower Eocene.' On page 105 we find a comment on the remarkable likeness between the brains of Mœritherium and the Sirenia.

Cranial and Dental Adaptations.—After these suggestive comments by Andrews were published, other specimens were secured by the American Museum Expedition of 1907 to the Fayûm, including two fairly well preserved skulls of *Mœritherium* (Fig. 42), which gave witness afresh to the general analogy of the skull of *Mœritherium* to that of the Sirenia. This material proves that *Mœritherium* not only had no proboscis, but that it was a totally different animal from *Phiomia* both in its appearance and habits and only very remotely related to it; this material proves further that in cænotelic adaptation the *Mœritherium* skull is closer to that of the sirenians and of the hippopotami than to that of any of the proboscideans. The cutting teeth, lips, and mouth parts of *Mœritherium* oppose each other in an entirely different manner than do those of *Phiomia*, so that it may be truly said that there

was not the least resemblance between either the mouth parts or the feeding habits of these two animals. In *Mœritherium* the nasal bones do not greatly recede, there was consequently little or no free retractile power of the upper lip, which is always the first step in the evolution of the proboscis as witnessed in living species of *Tapirus*. Comparison of the muzzle of *Mœritherium* with that of *Hyrax*, of *Castor*, of *Hippopotamus*, and of other mammals with an enlarged pair of front teeth, tends to show that the upper and lower lips were heavy and fleshy, and somewhat similar in form, in function, and in prehensile power; that the blunt tusks wore directly against each other and were entirely sheathed in enamel; that the lips were capable of closing over the tusks when the mouth was shut, somewhat as in the hippopotamus. The tusks were *adapted as feeding organs* rather than as fighting weapons, probably because *Mœritherium* was protected from attack by its partly aquatic habitat.

Second Restoration of Mœritherium and Phiomia by Osborn and Christman, 1908
Compare side views (Figs. 13 and 14)

Fig. 19. Front view of the head of *Mœritherium* with the eye and ear in position; the form and position of the nostrils somewhat conjectural. The eyes are seen to be very far forward, well raised toward the top of the face; the ears also are raised high on the side of the head; both these peculiarities are adaptations to aquatic life to bring these sense organs near to the surface of the water in swimming, so that they will emerge first and disappear last. As modeled by Erwin Christman, under the direction of Osborn, 1908.

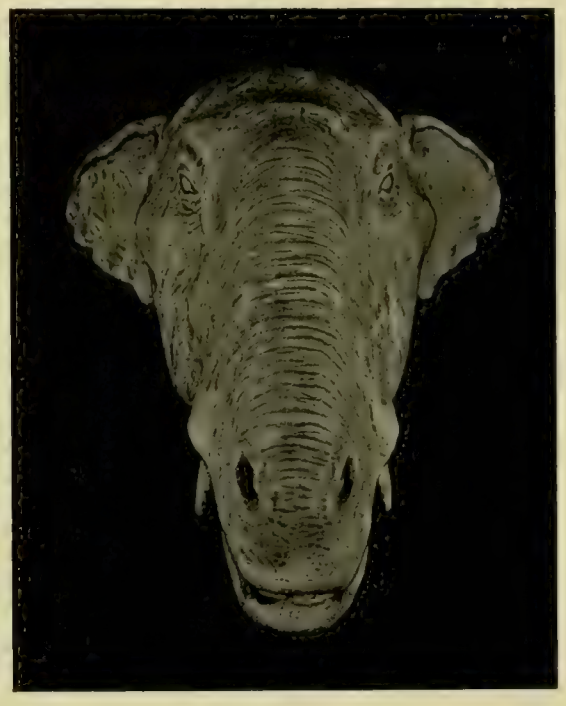


Fig. 20. Front view of the head of *Phiomia wintoni*, as modeled by Erwin Christman, under the direction of Osborn, 1908.

The above method of comparison of *Phiomia* and *Mœritherium* is that of making life-size models of the skulls in which the sense organs, such as the eye and the ear, are placed exactly in position, while the contours of the lips, nostrils, mouth parts, and external ears are largely conjectural. In Osborn's opinion (1926) the ear of *Phiomia* is erroneously restored, for it is much too elephantine. After Osborn, 1909.332, pp. 139, 140.

The conclusions drawn from the front teeth, I^2-I_2, from the simple bunodont grinding teeth, from the very short face (brachyopy), from the long cranium (dolichocrany), and from the extremely small bony eye sockets, are that *Mœritherium* was a confirmed and continual river-living animal, feeding mainly under water and along the banks of rivers, more specialized for aquatic life than the hippopotamus, as proven by its feeble pelvic bones, but far less specialized for aquatic life in its limb structure than the Sirenia.

This does not prove that *Mœritherium* is of the order Sirenia, as Osborn suggested in 1909; it is certainly an independent member of the Proboscidea, as Andrews originally maintained and as Matsumoto has stoutly contended. Its cranial *analogies* are with the sirenian skull; its cranial and dental *homologies* are with the Proboscidea. Its limbs and skeleton relate it to the primitive Proboscidea.

3. LOWLAND HABITS OF PHIOMIA, ANCESTOR OF THE AMEBELODONTINÆ

Phiomia without a Proboscis. The restoration-model of the head of *Phiomia* (=the *Palæomastodon* of the previous literature) also is *without* a proboscis but is provided with a stout upper lip which was capable of pressing closely against the procumbent paired lower incisor teeth. As Osborn observed (1909.332), *Phiomia* in all probability had not developed a proboscis. A profound difference between *Phiomia* and *Mœritherium* is brought out in comparing the front (Figs. 19 and 20) and side (Figs. 13 and 14) views of the head, in which it is seen that whereas the eyes of *Phiomia* are in the typical mammalian position above the first permanent grinder, those of *Mœritherium* are very far forward, well raised in the front part of the head, and of very diminutive size, as is shown by the shallowness of the eye sockets.

The distinctive peculiarity of *Phiomia* is that its eyes are in the position typical among mammals, that is, above the first true grinders, M^1-M_1. The reason that the eyes *appear* to be so far back is that the lower jaws are extended unusually far forward. The upper jaws *recede*, terminating at the sides in the sockets of the very sharp, laterally compressed tusks which at this stage of evolution were chiefly developed as fighting or defensive weapons, while only of indirect value as feeding organs. When the upper and lower lips are restored in such a manner as to enable the animal to close its mouth, the upper tusks are so largely covered by the lips that they are not especially prominent. In contrast with *Mœritherium* the nasal bones and narial openings in *Phiomia* deeply recede; thus a very wide space is left to be filled by the large retractile, prehensile upper lip which could undoubtedly be raised or lowered.

Evidence against a Proboscis.—The question now arises (Osborn, 1909.332, p. 140): "How far had this lip begun to transform into a proboscis? Was there a free projecting proboscis as represented in several previous restorations? A negative answer appears to be furnished by the structure and mode of wear of the lower incisors. Together these form a broad, protrusive, spoon-shaped feeding organ, which is invariably greatly worn on the upper surface and somewhat less at the ends. This worn upper surface seems to prove that in the prehension of food the edge of the upper lip was constantly pressed downward against these teeth, thus, with the aid of fine particles of grit and sand, which were occasionally taken in, causing wear. In brief, the food appears to have been seized between the upper lip and the spoon-shaped lower teeth. Palæomastodon was a browser, and this lip could be turned up and retracted effectively to pull down smaller branches, but there is no reason to suppose that it had the free curling and independent prehensile power which characterises a true proboscis. If we critically consider the theory of the animal possessing a proboscis of considerable length, we find it rests upon the idea of kinship with the elephant rather than upon careful study of the mouth parts themselves."

If *Phiomia* possessed an independent prehensile proboscis extending beyond the line of the mouth for the seizing of food, we cannot assign any function to the large and much worn paired lower incisor teeth; the most probable theory of their function, therefore, seems to be that shown in the model (Fig. 14), namely, the *prehension* of food by pressing the upper lip against the lower incisors, rather than the prehension of food by grasping with a long and flexible proboscis; this function is progressively developed in the Amebelodont successors of *Phiomia*, also without a proboscis.

The first rule in the restoration of adaptations is not to be too much influenced by kinship, but to adhere to the evidence afforded by the hard parts themselves. According to this rule *Phiomia had no proboscis;* it had a powerful upper lip which pressed against the tips of the lower incisor teeth. Osborn (1933) believes that this function was continued into the subfamily of the Amebelodontinæ (Longirostrines) to which *Phiomia* directly gave rise.

4. FOREST-LOVING HABITS OF PALÆOMASTODON. NOT ANCESTRAL TO MASTODON

One proof of the forest habits of *Palæomastodon* is the rarity of its fossil remains; forest-living animals are relatively rare.

The true *Palæomastodon*, typified by *Palæomastodon beadnelli* Andrews, 1901, and supplemented by the more recently described *Palæomastodon intermedius* Matsumoto, 1922, is only partly known, namely, the palate, the grinding teeth, and portions of the zygomatic arch; therefore we can only form a conjecture as to its habits from our knowledge of the animals which appear to be analogous to it, namely, the true mastodonts, known to be of forest-living habitat and of leaf-browsing habits. Consequently analysis of the habits of the Fayûm proboscideans

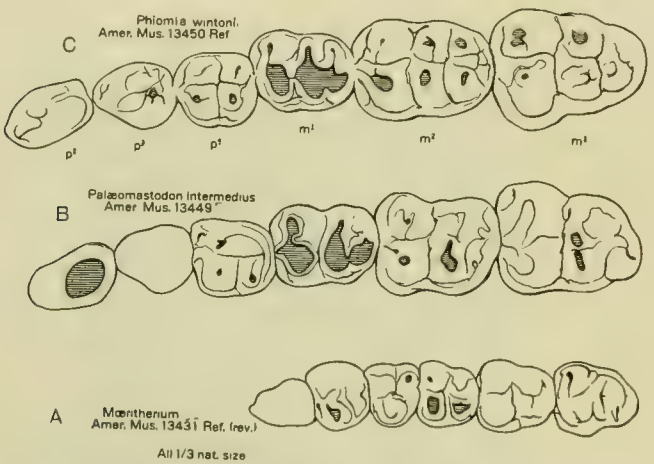


Fig. 21. Superior molars, compare Matsumoto, 1923, fig. 10: "*Mœritherium, Palæomastodon,* and *Phiomia.* Left upper grinding teeth. A, *Mœritherium,* Amer. Mus. No. 13431; B, *Palæomastodon,* Amer. Mus. No. 13449; C, *Phiomia,* Amer. Mus. No. 13450." All figures one-third natural size.

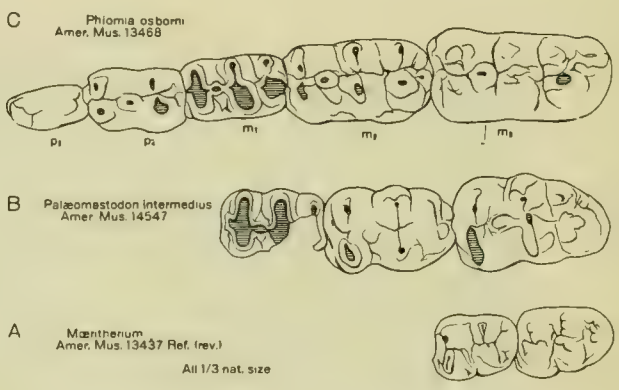


Fig. 22. Inferior molars, compare Matsumoto, 1923, fig. 11: "*Mœritherium, Palæomastodon,* and *Phiomia.* Left lower grinding teeth. A, *Mœritherium,* Amer. Mus. No. 13437 (reversed), second and third lower molars; B, *Palæomastodon,* Amer. Mus. No. 14547, first, second and third lower molars; C, *Phiomia,* Amer. Mus. No. 13468." All figures one-third natural size.

is incomplete in respect to this genus. It is certain that the habits and habitat were different from those of *Phiomia* and profoundly different from those of *Mœritherium.* We may therefore contrast these three Fayûm animals as follows:

Mœritherium	*Phiomia*	*Palæomastodon*
Rivers and swamps	Lowlands and savannas	Forests and savannas
1. Face abbreviated; cranium elongated.	1. Face elongated; cranium normal.	1. Facial and cranial proportions unknown.
2. Upper and lower second incisor tusks of equal size, directly opposed, sheathed in enamel; feeding, not fighting, organs.	2. Lower tusks horizontal, no enamel; upper tusks sharply pointed, recurved, enamel band on outer surface; fighting, not feeding, organs.	2. Tusks unknown. Upper tusks probably circular in section, with lateral enamel band.
3. Eye sockets extremely small, placed anteriorly; eyes and auditory openings elevated.	3. Eye sockets and auditory openings in normal position.	3. Eye sockets and auditory openings in normal position.
4. Upper and lower lips opposing each other.	4. Upper lip opposing lower incisors.	4. Upper lip probably forming a proboscis.
5. Molars short and broad, tetrabunodont.	5. Molars narrow and elongate, trilophodont, large *central conules*	5. Molars relatively broad, hexabunodont, subtrilophodont, central conules rudimentary.
6. Amphibious or aquatic in habit, hence rarely fossilized.	6. Shore or lowland habitat, hence frequently fossilized.	6. Probably of forest habitat, hence rarely fossilized.

IV. REVISION AND SYNOPSIS OF GENERA, SPECIES, AND TYPES OF THE FAYÛM PROBOSCIDEANS IN THE ORDER OF THEIR ORIGINAL DESCRIPTION

Revisions (1901–1923).—The Fayûm proboscideans described by Andrews (1901–1906), and added to by Pontier (1907), Schlosser (1911), Matsumoto (1922–1924), and Petronievics (1923), are so fundamentally important and so confused in the present literature that it is necessary to give them a revision by themselves prior to the phylogenetic consideration which they will receive in Chapters III, VI, and VIII of this Memoir. This

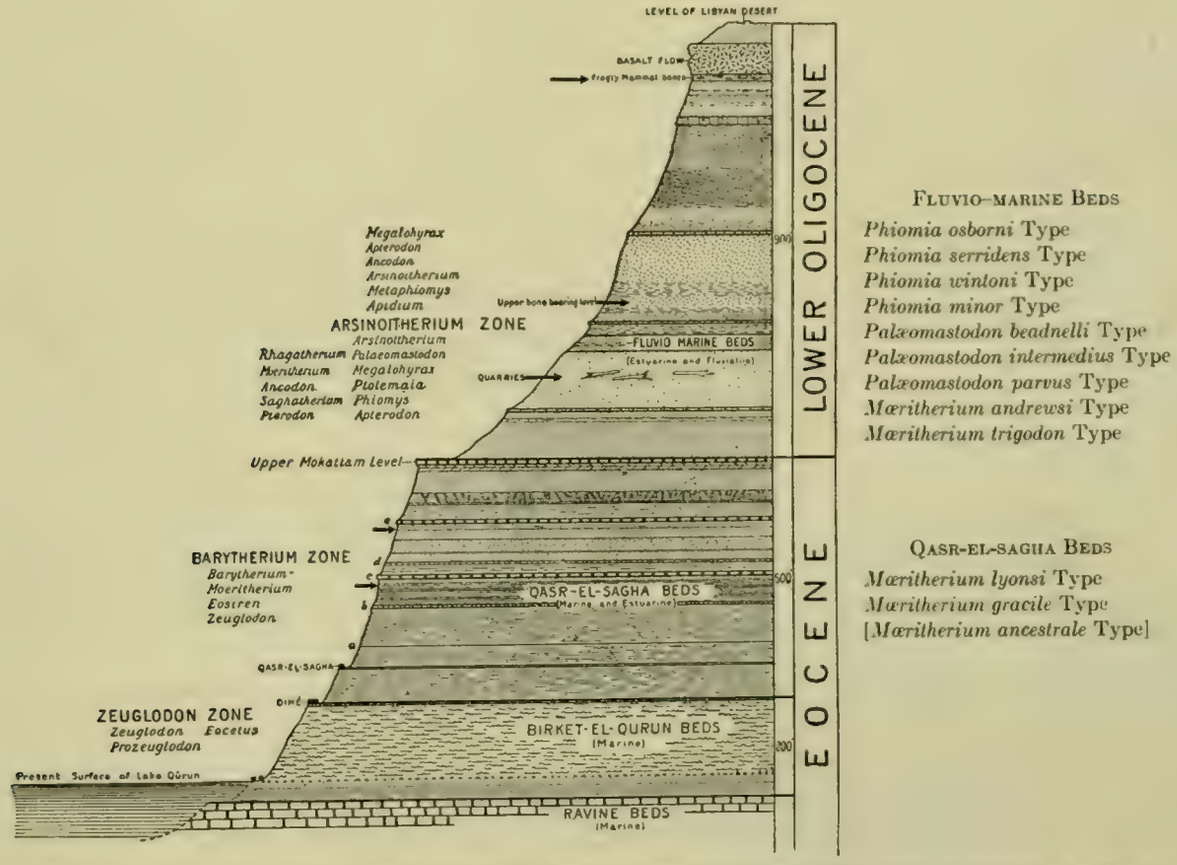


Fig. 23. Section through the Upper Eocene and Lower Oligocene formations north of Lake Qurun, Fayûm, Egypt Arrows indicate levels richest in remains of fossil mammals. Approximate geologic distribution of proboscidean types shown in right-hand column. After Andrews, Beadnell, Granger, and Osborn. Reproduced from Osborn, 1910.346, p. 199, fig. 89

revision is chiefly based on the authority of Dr. H. Matsumoto (1922, 1923, 1924), who reviewed the entire Fayûm collection of the American Museum and the original type collection of the British Museum for the purpose, inasmuch as neither Osborn nor Andrews had been able to verify these observations in detail. In 1905 Andrews (1905, p. 562) observed that the species of the genus *Palæomastodon* fall into two groups; in 1922 Matsumoto (1922, p. 1) divided these groups into two genera, viz.: *Palæomastodon* Andrews and *Phiomia* Andrews and Beadnell. In general Osborn accepts Matsumoto's main conclusions, which have a very important bearing on the phylogeny of the Proboscidea.

The geologic levels of the type and genotype specimens are indicated in the above diagram. The Qasr-el-Sagha beds are now regarded as Upper Eocene; the Fluvio-marine beds as Lower Oligocene.

SPECIES OF THE FAYÛM PROBOSCIDEA IN ORDER OF THEIR ORIGINAL DESCRIPTION

Key Numbers to Fig. 24	Original Name		Reference in Present Memoir
1.	Fluvio-marine beds	*Palæomastodon Beadnelli* Andrews, 1901	Genotype of *Palæomastodon*
2.	Qasr-el-Sagha beds	*Mœritherium lyonsi* Andrews, 1901	Genotype of *Mœritherium*
3.	Fluvio-marine beds	*Phiomia serridens* Andrews and Beadnell, 1902	Genotype of *Phiomia*
4.	Qasr-el-Sagha beds	*Mœritherium gracile* Andrews, 1902	= *Mœritherium gracile*
5.	Fluvio-marine beds	*Mœritherium trigodon* Andrews, 1904	= *Mœritherium trigodon*
6.	Fluvio-marine beds	*Palæomastodon minor* Andrews, 1904	= *Phiomia minor*
7.	Fluvio-marine beds	*Palæomastodon parvus* Andrews, 1905	= *Palæomastodon parvus*
8.	Fluvio-marine beds	*Palæomastodon wintoni* Andrews, 1905	= *Phiomia wintoni*
9.	Fluvio-marine beds	*Paleomastodon Barroisi* Pontier, 1907	= *Phiomia wintoni* (♀?) / *Phiomia minor* (♂?)
10.	Fluvio-marine beds	*Mœritherium Andrewsi* Schlosser, 1911	= *Mœritherium andrewsi*
11.	Fluvio-marine beds	*Palæomastodon intermedius* Matsumoto, 1922	= *Palæomastodon intermedius*
12.	Fluvio-marine beds	*Phiomia osborni* Matsumoto, 1922	= *Phiomia osborni*
13.	Qasr-el-Sagha(?) beds	*Mœritherium ancestrale* Petronievics, 1923	= *Mœritherium ancestrale*

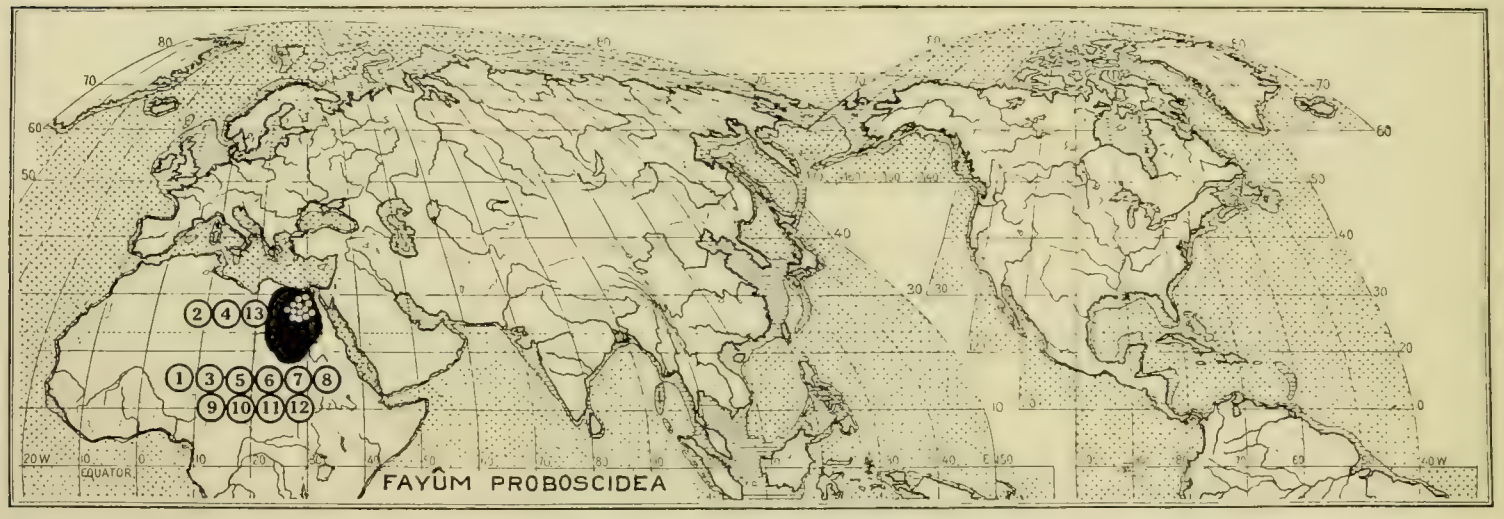


Fig. 24. Geographic distribution of species of the Fayûm Proboscidea according to the heavy face numerals in preceding list. The white dots within the black areas represent the approximate localities where the types of these thirteen species were found; the figures in the circles represent the species.

Mastodon [= *Phiomia*] *pygmæus* Depéret, 1897, from Algeria, omitted in this map (see Fig. 189).

Geologic Levels of Mœritherium Species.—The above chronologic list of species was corrected by Andrews himself as to geologic level; thus the genotype (*Mœritherium lyonsi*) as well as the type of *Mœritherium gracile* are both from the Qasr-el-Sagha beds, whereas a referred specimen of *Mœritherium lyonsi* (?) as well as the type of *Mœritherium trigodon* are from the overlying Fluvio-marine series. It is this referred specimen of *Mœritherium lyonsi* (?) which Schlosser selected as the type of *Mœritherium andrewsi*.

It is not known whether these smaller, intermediate, and larger species constitute two geologic ascending series; it is probable that they do.

Quarry Distribution Records.—The shifting river-channel sands and gravels in which the species of *Mœritherium*, *Phiomia*, and *Palæomastodon* were deposited are exposed in different quarries; the numerous specimens referable to these three genera and six species found by the American Museum Expedition of 1907 were recorded as occurring in Quarry A, Quarry B, and Quarry C, or at various distances from these chief quarries.

Perhaps future examination of these quarry (A, B, C) records will enable us to determine the relative geologic levels. So far as examined the American Museum quarry records do not indicate the separation of the species by the quarries, e. g., from Quarry B are recorded the following species: *Palæomastodon parvus*, a single specimen; *P. intermedius*, two specimens; *P. beadnelli*, one specimen; *Phiomia minor*, seven or more specimens; *P. wintoni*, thirty or more specimens. Thus the same Quarry B of the American Museum records contains three species of *Palæomastodon* and two species of *Phiomia*. This demonstrates that Quarry B represents a *very long period of deposition*. The very progressive species *Phiomia osborni* was found eight miles west of Quarry A; it undoubtedly represents a higher geologic level. See full quarry records in American Museum card catalogue, also as printed by Matsumoto (1923, 1924).

Geologic Levels of Palæomastodon and Phiomia Species.—Andrews informs us that the type of *Palæomastodon beadnelli* came from the very base of the Fluvio-marine series, 50 feet below the typical level of *Phiomia;* yet *P. beadnelli* is the largest and most progressive species of the true *Palæomastodon*. Unfortunately we have as yet no record of the geologic levels on which were found the type specimens into which six species of *Palæomastodon* and *Phiomia* are now divided, namely:

Large, progressive specific stages	*Phiomia osborni*	*Palæomastodon beadnelli*
Intermediate specific stages	*Phiomia wintoni*	*Palæomastodon intermedius*
Small, primitive specific stages	*Phiomia minor*	*Palæomastodon parvus*

The associated mammalian and reptilian fauna with these species of proboscideans is shown in the Andrews table (1906, p. ix) reproduced herewith.

Bartonian.		250	*Fluvio-marine Series* (4 in Section).—Variegated sands, sandstones, clays, and marls, with limestone-grits and thin bands of limestone. In the lower beds of this Series are large numbers of silicified trees associated with vertebrate remains, including:—*Arsinoitherium zitteli, A. andrewsi, Saghatherium antiquum, S. minus, S. magnum, S. majus, Megalohyrax eocænus, M. minor, Palæomastodon beadnelli, P. wintoni, P. parvus, P. minor, Mœritherium* (?) *lyonsi, M. trigonodon, Phiomia serridens, Ancodon gorringei, A. parvus, A.* sp., *Rhagatherium ægyptiacum, Geniohyus mirus, G. fajumensis, G. major, Hyænodon* sp., *Pterodon africanus, Apterodon macrognathus, Sinopa ethiopica, Eremopezus eocænus, Crocodilus articeps, C. megarhinus, Tomistoma gavialoides, Testudo ammon, T. beadnelli, T. isis, Stereogenys libyca, Podocnemis fajumensis, P. blanckenhorni* with var. *ovata, Pelomedusa progaleata, Aetobatis* sp.
	Upper Mokattam.	155	*Qasr-el-Sagha Series* (*Carolia Beds*) (5 in Section).—Alternating limestones, marls, clays, and sandstones. The vertebrate remains include:—*Mœritherium lyonsi, M. gracile, Barytherium grave, Eosiren libyca, Zeuglodon osiris, Crocodilus* sp., *Tomistoma africanum, Psephophorus eocænus, Thalassochelys libyca, Podocnemis antiqua, P. stromeri* and var. *major, Stereogenys cromeri, S. podocnemioides, Gigantophis garstini, Pterosphenus schweinfurthi, Fajumia schweinfurthi, Socnopæa grandis, Pristis fajumensis, P. ingens; Eopristis reinachi, Propristis schweinfurthi, Myliobatis* sp., *Carcharodon* sp.

Fig. 25. Complete faunal list (1906) of the Upper Eocene (155) Qasr-el-Sagha Series, also of the Lower Oligocene (250) Fluvio-marine Series of Andrews. After Andrews, 1906, p. ix. Compare figures 11, 12, and 23.

Original Descriptions and Present Reference.—The remaining pages of the present Chapter II are devoted to the firm establishment of Charles W. Andrews' *types, type figures, type descriptions*, and *type geologic levels*, in accord with the monographic system which prevails throughout this Memoir. It is a token of Andrews' signal ability as a palæontologist that he interpreted so accurately the chief characters of this proboscidean fauna from materials invariably scattered and more or less fractured in the course of fluvio-marine deposition. In *italics* is given Andrews' original reference, e.g., *Palæomastodon minor* Andrews, 1904; in heavy face is given the present generic and specific reference, e.g., **Phiomia minor** Andrews, 1904. It is earnestly hoped that these references, representing years of labor on the part of Andrews, Matsumoto, and the present writer, may stand and be accepted as a basis of future monographic research.

Palæomastodon beadnelli Andrews, 1901

Figures 2, 26, 34, 41, 41a, 90–95, 97; see also page 147

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

This was the first proboscidean to be described from the Fayûm and was properly given the name *Palæomastodon*, namely, the ancient *Mastodon*.

(Andrews, letter, 1922): The type was found at the very base of the Fluvio-marine beds, Lower Oligocene, 50 or 100 feet *below* the *Phiomia* level; this genotype specimen, with a very large femur and humerus, was the only true *Palæomastodon* material recovered.

Palæomastodon Beadnelli Andrews, 1901. Zoologist, Vol. V (4), August 15, 1901, pp. 318, 319 (Andrews, 1901.1); name only. Tageblatt des V Intern. Zoologen-Congresses, Berlin, No. 6, August 16, 1901, p. 4 (Andrews, 1901.2), notice; published volume (Verhandlungen) dated 1902, see especially p. 528. Geol. Mag., Dec. IV, N. S., Vol. VIII, pp. 400–409, September, 1901 (Andrews, 1901.3); description and figure. TYPE.—(*Op. cit.*, 1901.3, p.401): . . . "nearly complete left ramus of the mandible of a Proboscidean." In Andrews' supplementary description "A Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Fluvio-marine beds, Lower Oligocene, Fayûm, Egypt. TYPE FIGURE.—Andrews, 1901 3, p. 401, fig. 1, A, B.

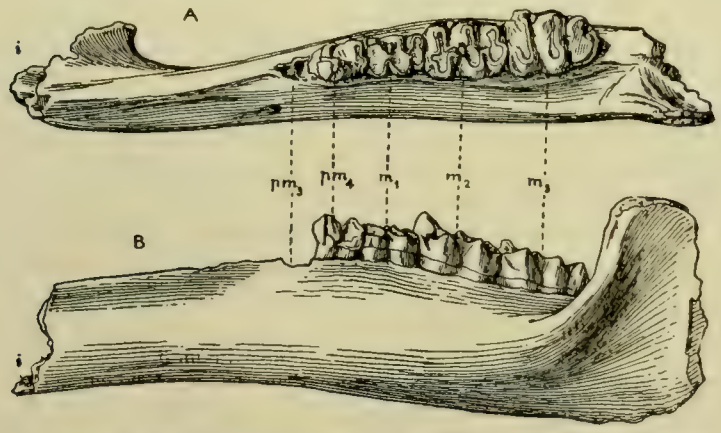


FIG. 1.—Left ramus of mandible of *Palæomastodon Beadnelli*. One-sixth natural size. (A) From above; (B) outer surface.

Fig. 26. Original type figure of *Palæomastodon beadnelli* Andrews, 1901. After Andrews, 1901.3, p. 401, fig. 1, A, B. (*Op. cit.*, p. 401): . . . "nearly complete left ramus of the mandible of a Proboscidean." Original (Geol. Mus., Cairo, C. 10014) destroyed; cast Brit. Mus. M. 8059; cast Amer. Mus. 9984. One-sixth natural size.

Egypt" (1906, p. 150, Pls. XII–XVI, text figs. 50, A, 51) the type specimen is given as "Left ramus of mandible with pm. 4 (broken) and m. 1–3 (Pl. XV, figs. 1, 1A); Geological Museum, Cairo." Original (Geol. Mus., Cairo, C.10014) destroyed in Custom House at Cairo; cast in British Museum (M.8059), also cast in American Museum (Amer. Mus. 9984). HORIZON AND LOCALITY.—

Andrews (1901.3, p. 401) observes: "One of the most important specimens found in the higher beds (probably Lower Oligocene) is the nearly complete left ramus of the mandible of a Proboscidean, which is in many respects similar to that of *Mastodon angustidens*, but belonged to a much smaller and in several respects more generalized form." Andrews (1904, p. 115) added the following measurements of the type and supposed female specimen of *P. beadnelli* in comparison with *P. minor:* "This species may be called *Palæomastodon minor;* its dimensions compared to those of *P. beadnelli* are shown in the following table . . .

	P. [= *Phiomia*] *minor*	*P. beadnelli* (? female)	*P. beadnelli* (type)
m. 3	47 mm.	65 mm.	78 mm.
m. 2	45 "	55 "	65 "
m. 1	32 "	41 "	48 "
pm. 4	28 "	39 "	48 "
pm. 3	28 "	30 "	?

Matsumoto (1922, p. 3) confirms Andrews' description of 1901 and adds Amer. Mus. 13481 as a referred specimen. In 1924 (p. 4) he distinguishes *Palæomastodon beadnelli* from *P. intermedius* and *P. parvus* as follows:

"3.—Length of lower molar series measuring 194 mm.; that of lower premolar and molar series, 285 mm. (Andrews' type)..... *beadnelli*

2.—Length of lower molar series measuring 159 mm. (type [Amer. Mus.] 14547); that of upper molar series, 150–152 mm. (paratype [Amer. Mus.] 13449); that of upper premolar and molar series, 250 mm. (ditto)..... *intermedius.*

1.—Length of lower molar series measuring 130 mm.; that of lower premolar and molar series, 197 mm. (Andrews' type)..... *parvus.*"

Mœritherium lyonsi Andrews, 1901

Figures 2, 27, 41a, 42, 42a, 43, 44, 49; see also page 72

Qasr-el-Sagha formation of the Fayûm, Egypt = Middle Eocene of Andrews = Upper Eocene of the present Memoir.

This was the second proboscidean to be described from the Fayûm and was very appropriately given the name *Mœritherium*, in reference to the ancient Lake Mœris of the Greeks.

Mœritherium lyonsi Andrews, 1901. Tageblatt des V Intern. Zoologen-Congresses, Berlin, No. 6, August 16, 1901, p. 4 (Andrews, 1901.2), notice; published volume (Verhandlungen) dated 1902, see especially p. 528. Geol. Mag., Dec. IV, N. S., Vol. VIII, pp. 400–409, September, 1901 (Andrews, 1901.3), description and figure; also "A Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt," 1906, p. 120, Pls. VIII, IX, X. TYPE.—(Andrews, 1906, p. 120):

"Mandible associated with upper molars and a dorsal vertebra." Geol. Mus., Cairo, C.10000; cast Amer. Mus. 9977. HORIZON AND LOCALITY.—Qasr-el-Sagha beds, Upper Eocene, Fayûm, Egypt. TYPE FIGURE.—Andrews, 1901.3, p. 404, fig. 2.

FIG. 2.—Dentition of *Mœritherium Lyonsi*. One-fourth natural size. (A) Upper teeth; (B) front of snout, showing the tusk-like second incisors; (C) left ramus of mandible from outer side.

Fig. 27. Original type figure of *Mœritherium lyonsi* Andrews, 1901. After Andrews, 1901.3, p. 404, fig. 2. (Andrews, 1906, p. 120): "Mandible associated with upper molars and a dorsal vertebra." Geol. Mus., Cairo (C. 10000); cast Amer. Mus. 9977. One-fourth natural size. (Andrews, 1901.3, p. 404, fig. 2): A, Upper teeth (C.10001) = paratype; A, B, portions of large skull, B showing front of snout with tusklike second incisors (C.10002, cast Amer. Mus. 9978) = paratype; C, left ramus of mandible from outer side (C. 10000) = type. (See Fig. 44.)

The referred *Mœritherium lyonsi* (?) recorded by Andrews in the overlying Fluvio-marine beds was chosen as the type of *Mœritherium andrewsi* by Schlosser. Matsumoto (1923, p. 124) distinguishes the two species of the Qasr-el-Sagha formation as follows:

"(1.) Larger form of the Qasr-el-Sagha Formation. Lower premolars very short: P^{2-4} [P_{2-4}], ca. 69 mm. (Andrews); lower molars very long, M_{1-3}, ca. 104 mm. (Andrews). All the lower cheek-teeth very wide. P_2, triangular, its widest part corresponding to the posterior lobe. P^{2-4}, 67–78 mm.; M^{1-3}, 85 mm. (Andrews).....*M. lyonsi.*

(2.) Smaller form of the Qasr-el-Sagha Formation. Lower premolars not very short in comparison with the length of lower molars: P_{2-4}, ca. 62 mm. (specimens in the American Museum); lower molars very short: M_{1-3}, 83 mm. (specimen in the American Museum). All the lower cheek-teeth are narrow. P^{2-4}, 62 mm. (Andrews); M^{1-3}, 75—ca. 79 mm. (Andrews).....*M. gracile.*"

Matsumoto (*op. cit.*, p. 125) adds the following information from the American Museum collection:

Amer. Mus. 13444; "two of the three fragments of mandibular rami of this specimen number appear to belong to this species. They are very peculiarly weathered, as a characteristic of the weathered specimens from the Qasr-el-Sagha Formation, with much-weathered and badly preserved molars *in situ*. Qasr-el-Sagha Formation of the Fayûm."

"The dimensions of the teeth of these fragments, in comparison with those of Andrews' specimens, are tabulated as follows (in mm.):

		Lower Teeth			Upper Teeth			
		[Amer. Mus.] 13444 ditto (Andrews)			(Andrews)			
P 2	length	..	..	22	27	..	..	.....
	width	..	..	16	23?	..	..	....
P 3	length	..	..	23	26.5	..	..	.....
	width	..	..	21	29.5	..	..	.....
P 4	length	..	..	25	23	..	..	.....
	width	..	..	23	27.5	..	..	.....
M 1	length	..	..	26.5	29	..	..	.....
	width	..	..	24.5	27	..	..	.....
M 2	length	29	28	35	26?	30	..	.....
	width	25	25	39	23.5	28	..	.....
M 3	length	40	39	42	....	32	..	37±[1]
	width	28	28	30	....	28	..	30±[1]
Length of P 2–4		..	..	69±[1]	68	..	67	.....
Length of M 1–3		..	..	104±[1]	....	..	85	.....

[1] "These dimensions are estimated from Andrews' figures."

Phiomia serridens Andrews and Beadnell, 1902

Figures 28, 180, 181; see also page 239

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

This was the third proboscidean to be described from the Fayûm and was appropriately given the name *Phiomia*, the Greek equivalent of the province now known as the Fayûm.

Phiomia serridens Andrews and Beadnell, 1902. "A Preliminary Note on Some New Mammals from the Upper Eocene of Egypt," Survey Dept., Pub. Works Ministry, Cairo, 1902, pp. 1–9 (original description); "Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt," Andrews, 1906, pp. 169–171 (supplementary description), Pl. XVIII, figs. 4, 4A. TYPE.—Anterior portion of a left mandibular ramus, bearing Di_2 and Dp_{2-3} *in situ;* Geological Museum, Cairo (C.10007); cast Amer. Mus. 9981. HORIZON AND LOCALITY.—Beds of the Fluvio-marine formation (Lower Oligocene), Fayûm, Egypt, north of Birket-el-Qurun. TYPE FIGURE.—Andrews and Beadnell, 1902, figs. 1, 2. Matsumoto (letter, 1921) remarks of the referred specimen shown in figure 3 (*op. cit.*, 1902) that it is not the type and not a proboscidean.

Matsumoto (letter, 1921): Schlosser first pointed out that this genus and species might be merely a juvenile form of a *Palæomastodon* [i. e., *Phiomia*] (Neues Jahrb. f. Min., Vol. I, Pt. I, 1905, p. 157, Referate); Andrews accepted Schlosser's view, after securing a beautifully preserved mandible of a very young *Palæo-*

mastodon [i.e., *Phiomia*] probably referable to *Ph. wintoni* (Andrews, Geol. Mag., Dec. V, N.S., Vol. IV, 1907, p. 97); though the type specimen is merely a very young individual, it shows certain indications that it might belong to the *wintoni-minor* type of *Palæomastodon* [i. e., *Phiomia*], as distinguished from the *beadnelli-parvus* type; moreover, the specific name *Phiomia serridens* antedates any of the specific names of the *wintoni-minor* type.

Matsumoto (1924.1, p. 14) remarks that the genotype of *Phiomia serridens* Andrews is a species probably identical with *Palæomastodon* [=*Phiomia*] *wintoni* Andrews, 1905; or possibly with *Palæomastodon* [=*Phiomia*] *minor* Andrews, 1904.

Osborn, 1924: The type (genotype) cast of *Phiomia serridens* is close in size to *P. wintoni;* this observation is validated by another but slightly larger milk tooth specimen, namely, Amer. Mus. 13458.

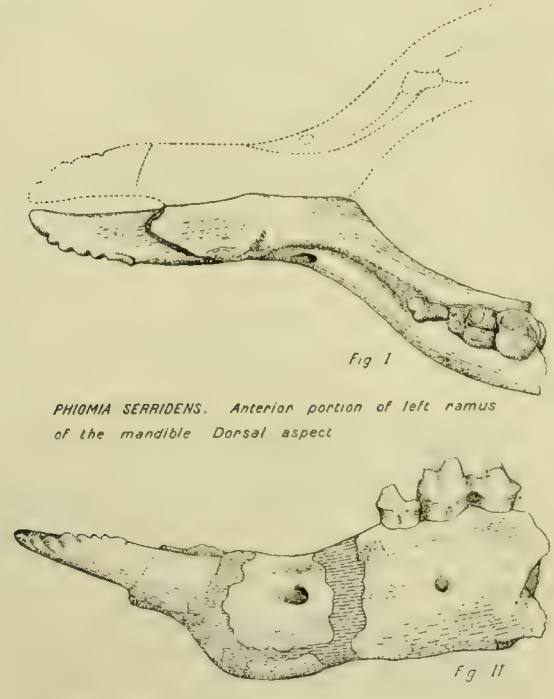


Fig. 28. Original type figure of *Phiomia serridens* Andrews and Beadnell, 1902. After Andrews and Beadnell, 1902, figs. 1 and 2. Anterior portion of a left mandibular ramus, bearing Di_2 and Dp_{2-3} *in situ;* Geol. Mus., Cairo (C. 10007), cast Amer. Mus. 9981. One-half natural size.

Mœritherium gracile Andrews, 1902

Figures 29, 41, 42a, and 45; see also page 73

Qasr-el-Sagha formation of the Fayûm, Egypt = Middle Eocene of Andrews = Upper Eocene of the present Memoir.

Mœritherium gracile Andrews, 1902. "Preliminary Note on some Recently Discovered Extinct Vertebrates from Egypt," Geol. Mag., Dec. IV, N. S., Vol. IX, pp. 291–295 (original description); "Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt," 1906, pp. 127, 128 (supplementary description), Pl. XVII, figs. 1, 2. TYPE.—(Andrews, 1906, p. 127): "An imperfect skull . . . including the palatal region, associated with cervical, dorsal, and lumbar vertebræ; Geological Museum, Cairo." Geol. Mus. Cairo [C.10003]; cast Amer. Mus. 9979. HORIZON AND LOCALITY.—(Andrews, 1906, p. 127): "Qasr-el-Sagha beds (Middle [Upper] Eocene): north of Birket-el-Qurun," Fayûm, Egypt. TYPE FIGURE.—Andrews, 1906, Pl. XVII, figs. 1, 2.

Matsumoto (1922, p. 5, 1923, p. 125) rightly characterizes *Mœritherium gracile* as the small species of the Qasr-el-Sagha beds. His definition of this species is as follows (*op. cit.*, 1923, p. 125):

> "(2.) Smaller form of the Qasr-el-Sagha Formation. Lower premolars not very short in comparison with the length of lower molars: P_{2-4}, ca. 62 mm. (specimens in the American Museum); lower molars very short: M_{1-3}, 83 mm. (specimen in the American Museum). All the lower cheek-teeth are narrow. P^{2-4}, 62 mm. (Andrews); M^{1-3}, 75—ca. 79 mm. (Andrews) . . . . . *M. gracile.*"

The additional information based on the American Museum collection from the Qasr-el-Sagha formation of the Fayûm is quoted below (Matsumoto, 1923, p. 128):

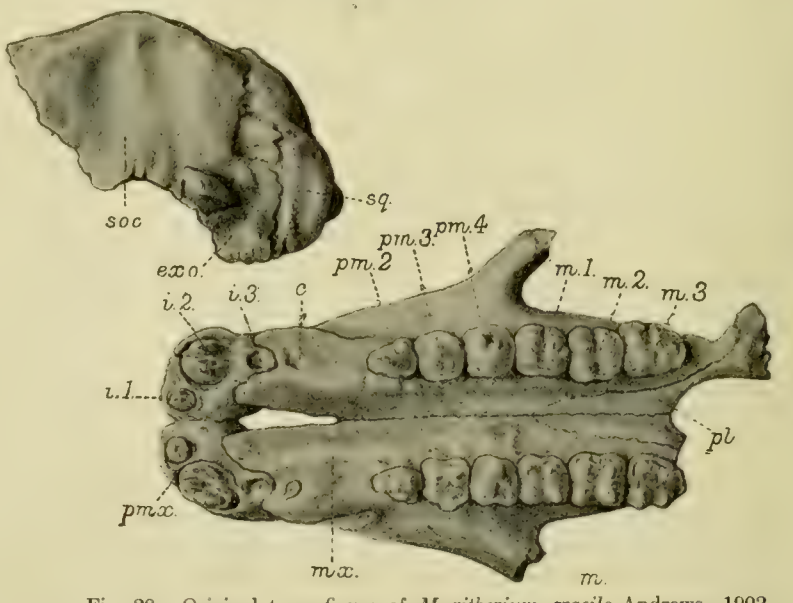


Fig. 29. Original type figure of *Mœritherium gracile* Andrews, 1902. After Andrews, 1906, Pl. XVII, figs. 1, 2. (*Op. cit.*, p. 127): "An imperfect skull . . . including the palatal region, associated with cervical, dorsal, and lumbar vertebræ;" Geol. Mus., Cairo (C. 10003), cast Amer. Mus. 9979. (Fig. 1) . . . "anterior portion of skull, palatal view: one-third nat. size. Qasr-el-Sagha beds (Middle Eocene)." (Fig. 2) . . . "occipital region of same skull, posterior view; one-third nat. size. Same horizon."

Amer. Mus. 13443; "mandible, with P_3-M_3 of the left side and M_{1-3} of the right side *in situ.* [Amer. Mus.] 13444; one of the three fragments of mandibular rami of this specimen number, with badly preserved molars *in situ.* [Amer. Mus.] 13445; fragment of a right mandibular ramus of a young individual, with the teeth broken away. [Amer. Mus.] 13446; fragment of a left mandibular ramus, with the crowns of the teeth broken away. All from the Qasr-el-Sagha Formation of the Fayûm."

"The mandible of [Amer. Mus.] 13443 measures 305 mm. in length without incisors, 8.5 mm. in length of symphysis, 55 mm. and 50 mm. in the distance between the two first molars and the two last molars respectively, 225 mm. in the bicondylar width and

76 mm. in the height of the mandibular ramus at M_1 without the teeth. In this specimen the symphysial depression already cited is observed to be present. In the fragmentary mandible of [Amer. Mus.] 13446, the same depression is clearly observed, also."

"The dimensions of the cheek-teeth of the specimens at hand, in comparison with those of Andrews, are tabulated as follows (in mm.):

		Lower Teeth			Upper Teeth	
		[Amer. Mus.] 13443 right-left		[Amer. Mus.] 13444	(Andrews)	
P 2	length	....	....	...	22	....
	width	....	....	...	18	....
P 3	length	....	22	...	20	....
	width	....	15	...	23	....
P 4	length	....	21	...	20	....
	width	....	18	...	21?	....
M 1	length	23	23	22	23	25
	width	20	19	19?	23	21
M 2	length	28	28	27	24	27
	width	22.5	23	22	25	23
M 3	length	34	33	...	28	28
	width	24	24	...	24	25
Length of P 2-4		63± (alveoli)	63± (ditto)	...	62	....
Length of M 1–3		84	84	...	75	79±[1]

[1] "This dimension is estimated from Andrews' figure."

"The alveoli of each I_1 and I^2 of the mandible of [Amer. Mus.] 13443 measure 10 mm. and 20 mm. in transverse diameter, respectively; the lateral extension of, and the minimum distance between, the two alveoli of lower tusks are 50 mm. and 9 mm. respectively. The two alveoli of first incisors are situated just below and anterior to the part corresponding to minimum distance between the two alveoli of tusks. Judging from these alveoli, the lower first incisors might be located not strictly inside, but inside and below and anterior to, the pair of lower tusks, which might be rather closely set to each other. These lower tusks appear to be distinctly smaller than those of *M. lyonsi* and *andrewsi*."

Mœritherium trigodon Andrews, 1904

Figures 30, 42, 42a, 46, 49; see also page 74

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

Mœritherium trigodon Andrews, 1904. "Further Notes on the Mammals of the Eocene of Egypt," Geol. Mag., 1904, Dec. V, N. S., Vol. I, pp. 109–115 (original description); "Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt," 1906, pp. 128, 129 (supplementary description, including change of name, i. e., *trigodon* to *trigonodon*). TYPE.—(Andrews, 1904, p. 112): . . . "portion of the right ramus of a mandible containing the three molars: of these m.3 is in perfect and unworn condition, while m.2 and m.1 have lost portions of their outer sides." Brit. Mus. M.8499: cast Amer. Mus. 9980. HORIZON AND LOCALITY.—(Andrews, 1906, p. 128): "Fluvio-marine beds (Upper Eocene [Lower Oligocene]); north of Birket-el-Qurun," Fayûm, Egypt. TYPE FIGURE.—Andrews, 1906, Pl. IX, fig. 5.

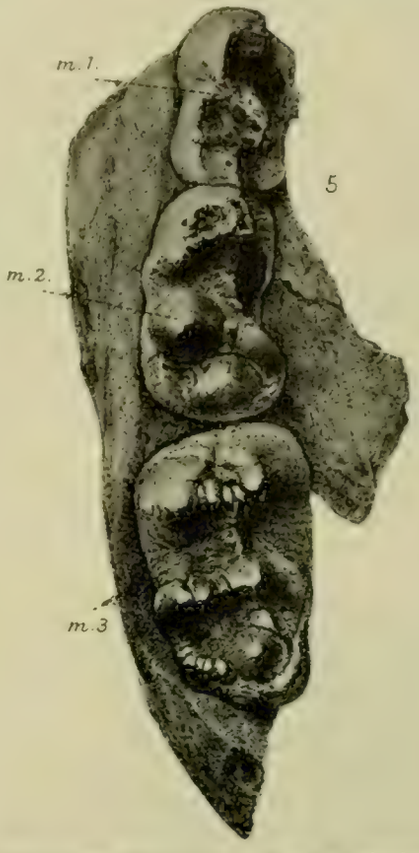


Fig. 30. Original type figure of *Mœritherium trigodon* Andrews, 1904. After Andrews, 1906, Pl. IX, fig. 5. (Andrews, 1904, p. 112): . . . "portion of the right ramus of a mandible containing the three molars: of these m.3 is in perfect and unworn condition, while m.2 and m.1 have lost portions of their outer sides." Brit. Mus. M.8499; cast Amer. Mus. 9980. Natural size.

MATSUMOTO, 1923, p. 134.—*Mœritherium trigodon* is a smaller form of the Fluvio-marine formation. In revising the American Museum collection, Matsumoto refers the following specimens to this species (p. 134):

Amer. Mus. 13430; "greater part of a full-grown skull, bearing all the upper cheek-teeth *in situ*."

Amer. Mus. 13431; "fragment of a skull, including a greater part of a right half of palate, bearing P^3-M^3 *in situ*."

Amer. Mus. 13433; "left M^2 attached to a fragment of upper jaw."

Amer. Mus. 13435; "fragment of a right ramus of mandible, with all the cheek-teeth *in situ*."

Amer. Mus. 13436; "fragment of a left ramus of mandible, with all the cheek-teeth *in situ*."

Amer. Mus. 13439; "right P_4 and M_1, with their roots broken away."

On this material *M. trigodon* is redefined as follows (Matsumoto, 1923, p. 125):

"(4.) Smaller form of the Fluvio-marine Formation. Lower premolars not very short in comparison with the length of lower molars: P_{2-4}, ca. 63 (specimen in the American Museum)—70 mm. (ditto, as well as Andrews); lower molars rather short: M_{1-3}, 93 (specimens in the American Museum)—98 mm. (Andrews). All the lower cheek-teeth very narrow: P_2, fusiform in upper view, its widest part corresponding to the middle part. P^{2-4}, 60–63 mm. (specimen in the American Museum); M^{1-3}, 83–85 mm. (ditto). Skull, small and lightly built. Sagittal and occipital crests very strong. Zygomatic width very large in comparison with the length of skull. Distance between the external auditory openings, as well as the width of occiput, very large..... *M. trigodon.*"

Matsumoto (*op. cit.*, p. 134) gives a detailed description of the six specimens in the American Museum listed above as referred to this species, concluding (p. 137) with the detailed measurements of the grinding teeth as follows (in mm.):

	P. [=*Phiomia*] *minor*	*P. beadnelli* (?female)	*P. beadnelli* (type)
m. 3	47 mm.	65 mm.	78 mm.
m. 2	45 "	55 "	65 "
m. 1	32 "	41 "	48 "
pm. 4	28 "	39 "	48 "
pm. 3	28 "	30 "	?

	Lower Teeth						Upper Teeth			
	[Amer. Mus.]			(Andrews)			[Amer. Mus.]			
	13435	13436	13439				13430	13431		13433
							right	left		
P 2 length	19.5	23?	....	..	23	..	19	22?	....	....
P 2 width	10	11	....	..	11	..	21	18?	....	....
P 3 length	22	24?	....	..	25	..	23	23.5	24	....
P 3 width	15	14?	....	..	17	..	26	24?	25?	....
P 4 length	23	23.5	25	..	24	22	20.5	20	22	....
P 4 width	18	18.5	19	..	20	..	24	23?	25.5	....
M 1 length	27	24	27.5	26	..	27	25	22	24	....
M 1 width	21	19	21	..	..	21	25	26.5?	24	....
M 2 length	29	31	....	32	..	..	29	28	30	29
M 2 width	24	24	....	..	..	..	28	27	25?	24
M 3 length	37	37	....	40	..	..	31	32	30	....
M 3 width	26.5	25	....	24	..	..	26.5	27	26	....
Length of P 2-4	63	70	....	..	70	..	60	63	....	....
Length of M 1–3	93	93	....	98	..	..	85	83	84	....

Phiomia minor Andrews, 1904

Figures 31, 34, 178, 179, 182, 183; see also page 239

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

Palæomastodon minor Andrews, 1904. "Further Notes on the Mammals of the Eocene of Egypt," Geol. Mag., 1904, Dec. V, N. S., Vol. I, p. 115 (original description); "Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt," 1906, pp. 168, 169 (supplementary description), Pl. XIV, figs. 1, 1A, and text fig. 50 D, p. 143. TYPE.—(Andrews, 1904, p. 115): . . . "part of the ramus [right] and the coronoid process of an immature mandible, in which m.3 has not yet been cut, although it is completely developed." Brit. Mus. M.8479b; cast Amer. Mus. 9982. HORIZON AND LOCALITY.—(Andrews, 1906, p. 168): "Fluvio-marine beds (Upper Eocene [Lower Oligocene]): north of Birket-el-Qurun," Fayûm, Egypt. TYPE FIGURE.—Andrews, 1906, Pl. XIV, figs. 1, 1A, and text fig. 50 D, p. 143.

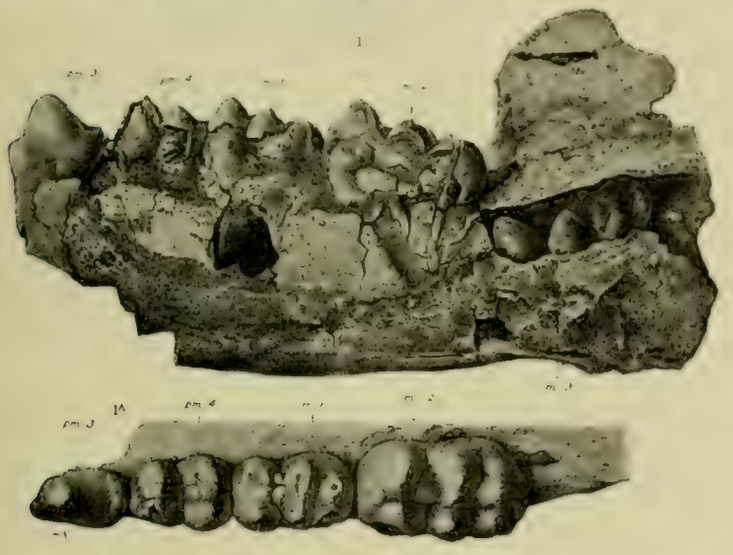
TYPE DESCRIPTION.—(Andrews, 1904, p. 115): "A portion of the right ramus of a mandible shows that there existed in the Upper Eocene beds a species of *Palæomastodon* considerably smaller than *P. beadnelli*, even allowing for a very wide range of individual variation in size in that species. . . . This species may be called *Palæomastodon minor*; its dimensions compared to those of *P. beadnelli* are shown in the following table . . .

(Andrews, notes, 1922): "These measurements [of *P. beadnelli*] are no doubt from a specimen of *P. wintoni*."

Matsumoto (1924.1, p. 16) reviews the type of *Palæomastodon minor* Andrews and transfers it to the genus *Phiomia*. He then compares it very carefully with specimens *referred* by Andrews to *Palæomastodon beadnelli* and to *P.* [*Phiomia*] *wintoni*, also with the type of *Palæomastodon barroisi* Pontier, and concludes that *Phiomia minor* is a valid species which may be clearly distinguished from both *Phiomia wintoni* and *P. osborni*.

He refers to *Phiomia minor* (1924, pp. 18, 19) eighteen specimens in the American Museum collection, of which the principal numbers are the following (also Matsumoto, 1922, p. 3): American Museum referred specimens Nos. 13469, 13471, 13475, 13483,

13486, 13448, 13455, 13461, 13464, 13465, 13467. Of the total number of eighteen specimens it is important to note that Quarry B and vicinity yielded ten specimens; Quarry B also yielded *Phiomia wintoni* in abundance. Quarry A yielded three specimens of *P. minor*, also *P. wintoni;* one important specimen, namely, Amer. Mus. 13469, was found eight miles west of Quarry A.



TYPE OF PHIOMIA MINOR

Fig. 31. Original type figure of *Palæomastodon minor* Andrews, 1904. After Andrews, 1906, Pl. XIV, figs. 1, 1A, and text fig. 50 D (see present Memoir Fig. 34D), p. 143. (Andrews, 1904, p. 115): . . . "part of the ramus [right] and the coronoid process of an immature mandible, in which m.3 has not yet been cut, although it is completely developed." Brit. Mus. M.8479b, cast Amer. Mus. 9982. One-half natural size.

The following (Matsumoto, 1924.1, p. 20) are the detailed measurements of the mandibles:

"The mandibles of the specimens Nos. 13469, 13471 and 13475, in comparison with one described by Andrews, measure as follows (in mm.).

NORMAL AND VARIANT CHARACTERS OF P. MINOR (MATSUMOTO, 1924.1, PP. 19–21).—(1) Amer. Mus. 13469 bears an extra pair of incisors, I_3 or C, just behind the enlarged I_2 or C; these extra teeth are either third incisors or canines. (2) Mandible of Amer. Mus. 13471 very large in its dimensions [referable to *Phiomia wintoni*]. (3) Skull (Amer. Mus. 13448) bearing all the upper cheek teeth, P^2-M^3, measured and described by Matsumoto in detail.

Palæomastodon parvus Andrews, 1905

Figures 32 and 34; see also page 146

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

Palæomastodon parvus Andrews, 1905. "Note on the Species of *Palæomastodon*," Geol. Mag., 1905, Dec. V, N. S., Vol. II, pp. 562, 563 (original description); "Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt," 1906, pp. 162–168 (supplementary description), text figs. 50C, p. 143, and 55, p. 163. TYPE.—(Andrews, 1905, p. 562): . . . "right ramus of the mandible, with the premolars and molars *in situ*, though somewhat crushed." Brit. Mus. M.8479a; cast Amer. Mus. 9976. HORIZON AND LOCALITY.—(Andrews, 1906, p. 163): "Fluvio-marine beds (Upper Eocene [Lower Oligocene]): north of Birket-el-Qurun," Fayûm, Egypt. TYPE FIGURE.—Andrews, 1906, text figs. 50 C, p. 143, and 55, p. 163.

TYPE DESCRIPTION (Andrews, 1905, p. 562).—In his paper Andrews observes the *two* sections of *Palæomastodon*, subsequently separated by Matsumoto into *Palæomastodon* and *Phiomia:*

"The species of *Palæomastodon* fall into two sections, in one of which the posterior end of the symphysis of the mandible is situated considerably in front of the level of the anterior premolar, while in the other it is only very little in front of that point. The first group, moreover, is distinguished by the comparative simplicity of the molars, in which the accessory cusps are scarcely at all developed, and by the small size of the talon of the last lower molar; into this subdivision the original species, *P. beadnelli*, falls,

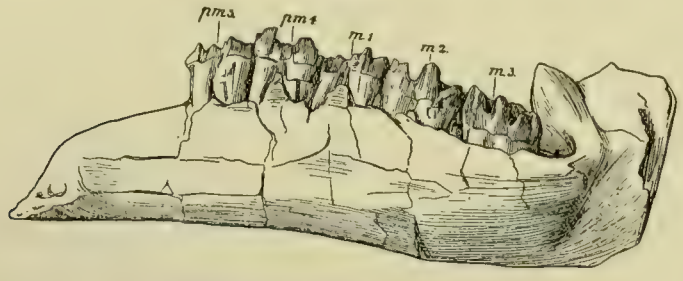
MEASUREMENTS OF PHIOMIA MINOR AMER. MUS. 13471 = PHIOMIA WINTONI	[Amer. Mus.] 13469 Young; prob. ♀	[Amer. Mus.] 13471 prob. ♂	[Amer. Mus.] 13475 Young; prob. ♀	Andrews prob. ♂
Length from Tip of Symphysis to Posterior Side of Angle	435±	590±	....	600
Length of Symphysis	137	215	....	226
Length from Tip of Symphysis to Posterior Side of M_3	....	435	....	475
Minimum Antero-posterior Width of Ascending Bar	122	155	...	....
Maximum Width of Anterior Half of Symphysial Region	65	....	...	....
Minimum Width at the Constriction of Symphysial Region	60	....	....	55
Height of Ramus at P_3	61	83	70	....
Ditto at M_1	59	90	72	....
Ditto at Anterior Lobe of M_3	....	82	....	....
Height of Ascending Bar at Condyle	112±	190	....	....

together with a much smaller form for which the name *P. parvus* is now proposed. The type-specimen of this new species is the right ramus of the mandible, with the premolars and molars *in situ*, though somewhat crushed."

Matsumoto (1922, p. 2) confirms Andrews' type description of 1905 and type figure of 1906 and adds as a single American Museum specimen No. 13497 from the upper Fluvio-marine formation of the Fayûm. (Matsumoto, 1924.1, p. 4): "Length of lower molar series measuring 130 mm.; that of lower premolar and molar series, 197 mm. (Andrews' type). . . . [*P.*] *parvus*." (*Op. cit.*, p. 4): "[Referred] Specimen.—[Amer. Mus.] No. 13497; a left lower third molar; Amer. Mus. Exp. 1907, Quarry B, Fluvio-marine formation, Fayûm, Egypt. This tooth measures 52 mm. in length and 32 mm. in width. It is longer than and as wide as the lower third molar of Andrews' type, which is stated by Andrews to be 46 mm. long and about 32 mm. wide."

Osborn, 1924: Osborn confirms Andrews' and Matsumoto's opinion as to the specimens of *P. parvus*, namely, the unique type and the referred specimen, and gives a description also measurements in comparison with *Palæomastodon beadnelli* and *P. intermedius* (Chap. VI, pp. 143, 146, 147).

Text-fig. 55.



Right ramus of mandible of *Palæomastodon parvus*. Type specimen.

Fig. 32. Original type of *Palæomastodon parvus* Andrews, 1905. After Andrews, 1906, text fig. 55, p. 163 (see also our Fig. 34C). (Andrews, 1905, p. 562): . . . "right ramus of the mandible, with the premolars and molars *in situ*, though somewhat crushed." Brit. Mus. M.8479a; cast Amer. Mus. 9976. One-fourth natural size.

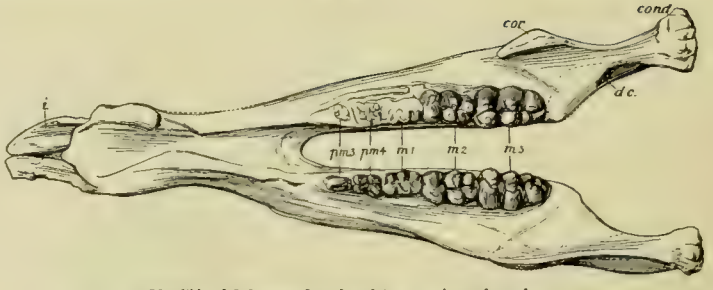
Phiomia wintoni Andrews, 1905

Figures 33, 34, 178, 179, 182, 183; see also page 241

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

Palæomastodon wintoni Andrews, 1905. "Note on the Species of *Palæomastodon*," Geol. Mag., 1905, Dec. V, N. S., Vol. II, pp. 562, 563 (original description); "Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt," 1906, pp. 156–162 (supplementary description), text fig. 53, p. 157. TYPE.—(Andrews, 1905, p. 563): . . . "a mandible with the incisors and posterior molars *in situ*." (Andrews, 1906, p. 156): "A mandible wanting the angular region and the anterior cheek-teeth. . . ; British Museum." Brit. Mus. M.8414. Cast (Amer. Mus. 14557) of two teeth from type mandible, r. $M_{2\text{-}3}$. HORIZON AND LOCALITY. — (Andrews, 1906, p. 157): "Fluvio-marine beds (Upper Eocene [Lower Oligocene]): north of Birket-el-Qurun," Fayûm, Egypt. TYPE FIGURE.—Andrews, 1906, p. 157, text fig. 53.

Text-fig. 53.



Mandible of *Palæomastodon wintoni*, type specimen, from above.

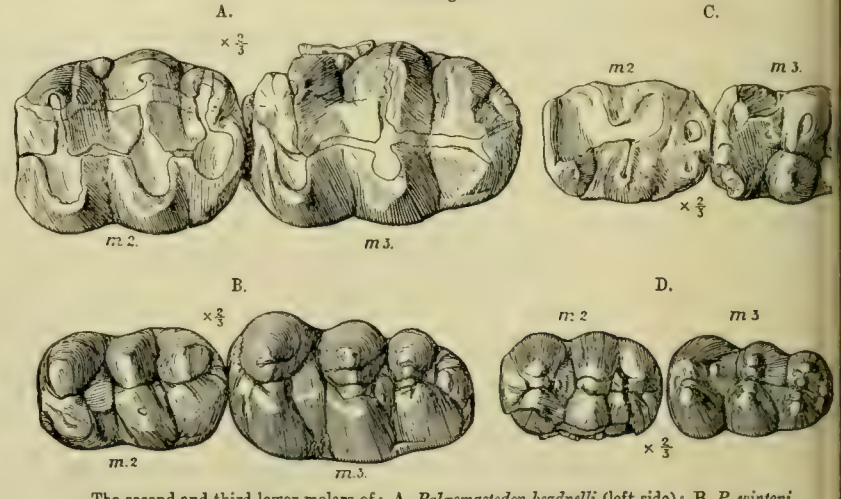
cond., condyle; *cor.*, coronoid process; *d.c.*, dental canal; *i.*, incisor. The premolars and first molar on the left side have been restored from another specimen.

TYPE OF PHIOMIA WINTONI

Fig. 33. Original type figure of *Palæomastodon wintoni* Andrews, 1905. After Andrews, 1906, text fig. 53, p. 157. (Andrews, 1905, p. 563): . . . "a mandible with the incisors and posterior molars *in situ*." (Andrews, 1906, p. 156): "A mandible wanting the angular region and the anterior cheek-teeth . . . ; British Museum." Brit. Mus. M.8414; cast Amer. Mus. 14557. One-eighth natural size.

TYPE DESCRIPTION.—(Andrews, 1905, p. 563): . . . "the other is a much larger form, and is important as being probably the commonest of all the species; for this the name *P. wintoni* is suggested, in honour of Mr. W. E. de Winton, by whom the expenses of my third collecting trip to the Fayûm were defrayed. It is considerably larger than *P. parvus* and *P. minor*, but smaller than *P. beadnelli*. From this last species it is also distinguished by (1) the extension back of the symphysis so that its posterior end is only just in front of the anterior premolar; (2) the position of the mental foramen on the side of the symphysis instead of behind it; (3) the greater complication of the molars and their greater length in proportion

Text-fig. 50.



The second and third lower molars of: A, *Palæomastodon beadnelli* (left side); B, *P. wintoni* (left side); C, *P. parvus* (right side); D, *P. minor* (right side). All ⅔ nat. size.

Fig. 34. After Andrews, 1906, text fig. 50, p. 143, all reduced from two-thirds to one-half natural size. Type second and third lower molars, as named in the present Memoir.

A, Type: *Palæomastodon beadnelli* (left side), type specimen, Cairo Museum, M_2 and M_3. B, Type: *Phiomia wintoni* (left side), type specimen, British Museum, M_2 and M_3. C, Type: *Palæomastodon parvus* (right side), type specimen, British Museum, M_2 and M_3. D, Type: *Phiomia minor* (right side), type specimen, British Museum, M_2 and M_3.

to their width; the last lower molar consists of three transverse crests and a distinct talon. The type-specimen is a mandible with the incisors and posterior molars *in situ*."

P. WINTONI REVISION.—Matsumoto (1922, p. 3) points out that the immature type of *Phiomia serridens* [see also *P. minor*], referred specimens of *Palæomastodon beadnelli* Andrews, 1901, and cotypes of *Paleomastodon barroisi* Pontier, 1907, may all belong to the same animal, namely, *Phiomia wintoni* Andrews, 1905. He also adds *twenty-seven* referred specimens from the American Museum collection of 1907. Matsumoto (1924.1, pp. 24–40) gives a clear and very able review of the characters of this dominant species, referring to it fifty-five specimens in all.

Phiomia barroisi Pontier, 1907

Figure 35

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

Synonym of *Phiomia minor* and of *P. wintoni*.

Paleomastodon Barroisi Pontier, 1907. "Sur une espèce nouvelle de Paleomastodon (*Paleomastodon Barroisi*)." Ann. Soc. géol. du Nord, XXXVI, pp. 150–154. TYPE.—Last left superior and inferior molars. HORIZON AND LOCALITY.—Bartonien of the Fayûm, Egypt. TYPE FIGURES.—Pontier, 1907, pp. 150, 151, text figs. 1, 2.

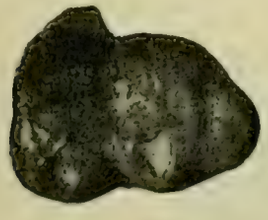


FIG. 1
Paleomastodon Barroisi Pontier
Arrière molaire superieure gauche
Echelle · 3/5.

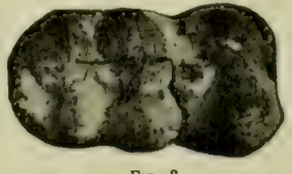


FIG. 2
Paleomastodon Barroisi Pontier.
Arrière molaire inférieure gauche.
Echelle : 3/5.

Fig. 35. Type figures of *Paleomastodon Barroisi* Pontier, 1907. After Pontier, 1907, pp. 150 and 151, text figs. 1 and 2. Last left superior and inferior molars. Three-fifths natural size.

Matsumoto (1922, p. 3) considers that *Paleomastodon barroisi* is a synonym in part of *Phiomia minor* Andrews, 1904, and in part of *Phiomia wintoni* Andrews, 1905. He observes (1924.1, p. 16, footnote): "The last lower molar of Pontier's two cotypes falls within the limit of variation of *P. minor;* it may belong to the supposed male types of the same species." (*Op. cit.*, p. 24, footnote) "The last upper molar of Pontier's two cotypes appears to me to belong to the presumed female type of the species [*P. wintoni*]."

Osborn, 1924: Osborn confirms Matsumoto's reference and considers that the two cotypes of *Palæomastodon barroisi* Pontier may come within the limits of male and female specimens of *Phiomia minor* and of *P. wintoni*.

Mœritherium andrewsi Schlosser, 1911

Figures 2, 36, 37, 41, 42, 42a, 46, 49, 51; see also page 74

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

Mœritherium Andrewsi Schlosser, 1911. "Beiträge zur Kenntnis der Oligozänen Landsäugetiere aus dem Fayûm: Ägypten." Beitr. Pal. Geol. Österr.-Ung., XXIV, p. 130. TYPE.— A young, nearly complete skull, Geological Museum, Cairo (C.7867), cast Amer. Mus. 9983; paratypes, also based on specimens referred by Andrews to *Mœritherium lyonsi*, namely, right and left series of lower premolars and molars in almost perfect preservation (Brit. Mus. M.8501), right lower premolars of another individual (Cairo Mus. C.8127), and right upper premolars of a large individual (Brit. Mus. M.8500). HORIZON AND LOCALITY.—(Andrews, 1906, Pl. IX): "Fluvio-marine beds (Upper Eocene [Lower Oligocene])," Fayûm, Egypt. TYPE FIGURE.—Andrews, "Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt," 1906, Pls. VIII, IX (skull and teeth from the Fluvio-marine formation provisionally referred to *M. lyonsi* by Andrews).

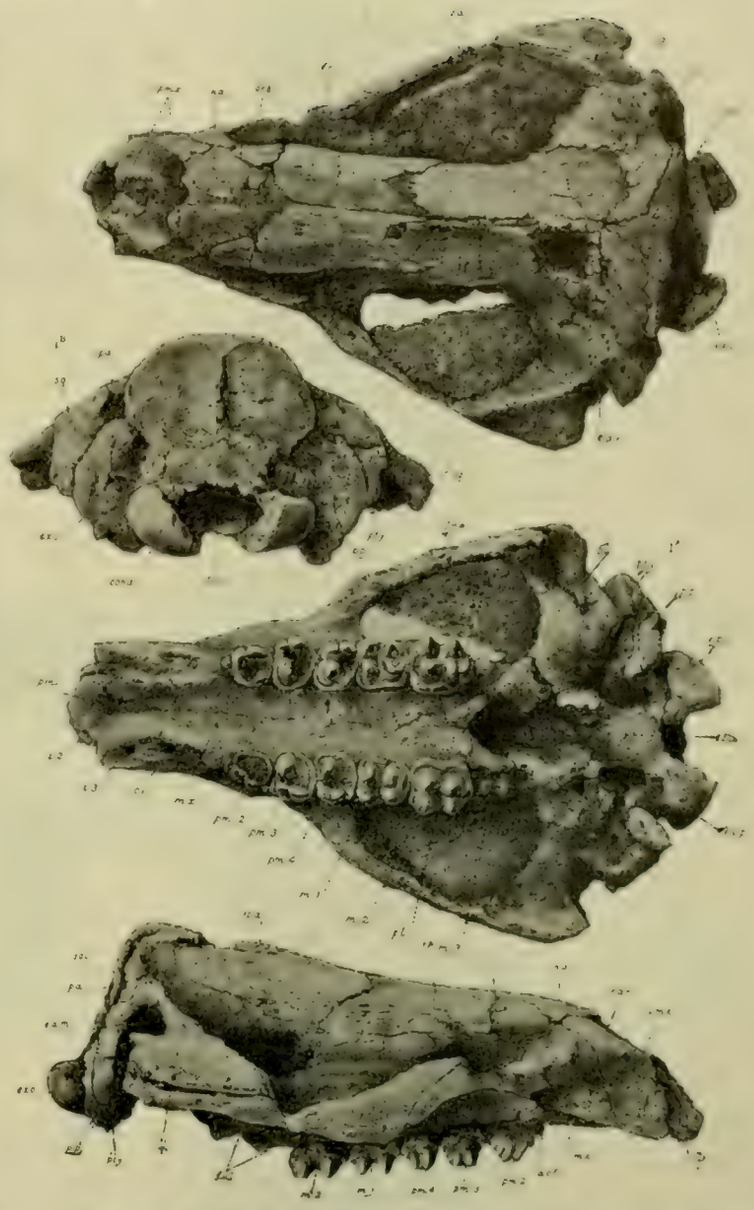


Fig. 36. Type figure of *Mœritherium Andrewsi* Schlosser, 1911. After Andrews, 1906, Pls. VIII and IX; specimens provisionally referred to *Mœritherium lyonsi* by Andrews. Geological Museum, Cairo (C. 7867); cast Amer. Mus. 9983. One-fourth natural size.

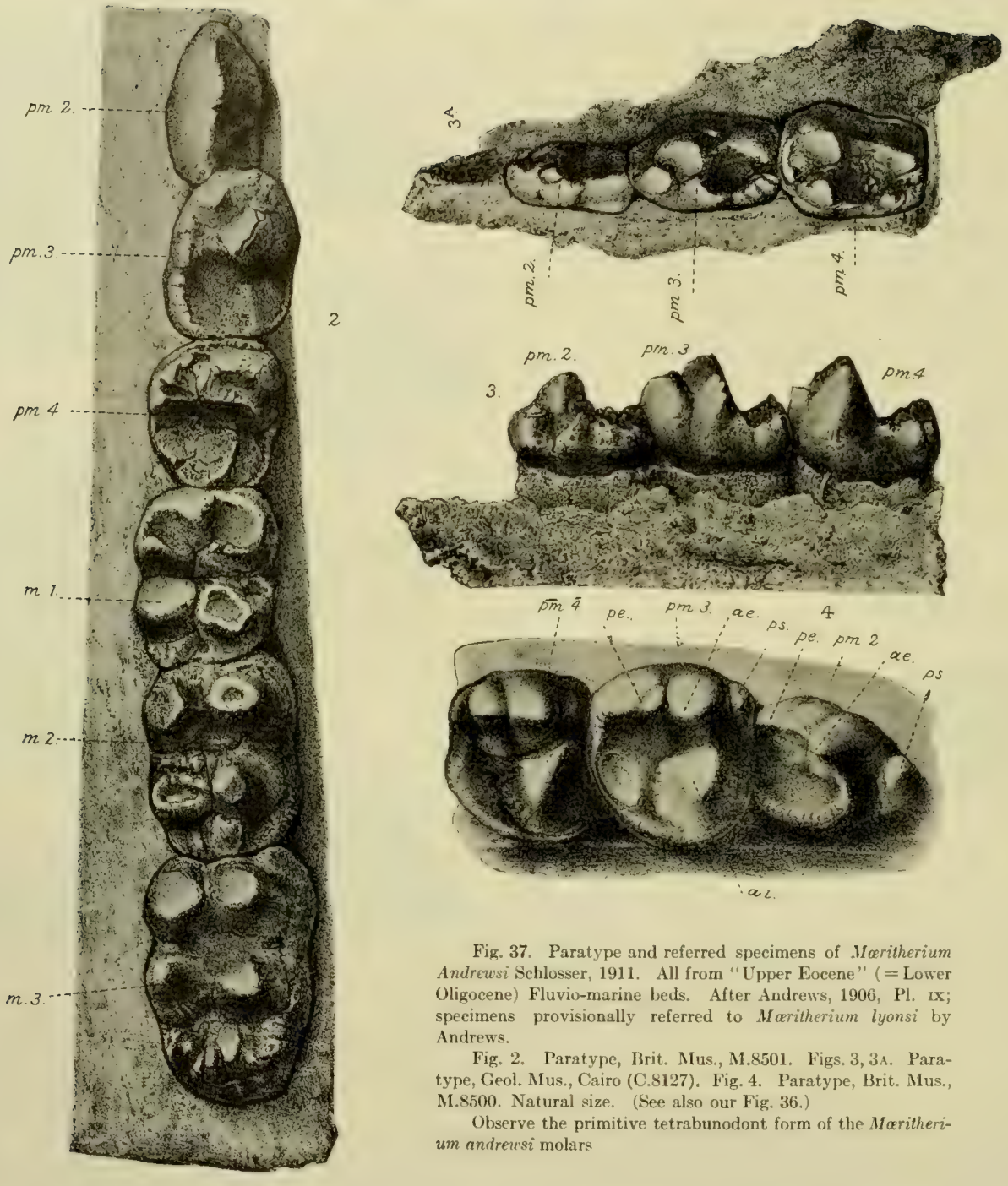


Fig. 37. Paratype and referred specimens of *Mœritherium Andrewsi* Schlosser, 1911. All from "Upper Eocene" (= Lower Oligocene) Fluvio-marine beds. After Andrews, 1906, Pl. IX; specimens provisionally referred to *Mœritherium lyonsi* by Andrews.

Fig. 2. Paratype, Brit. Mus., M.8501. Figs. 3, 3A. Paratype, Geol. Mus., Cairo (C.8127). Fig. 4. Paratype, Brit. Mus., M.8500. Natural size. (See also our Fig. 36.)

Observe the primitive tetrabunodont form of the *Mœritherium andrewsi* molars

Matsumoto (1922, p. 5) confirms Schlosser's definition of *Mœritherium andrewsi* based on the larger form from the Fluvio-marine (skull, Geol. Mus., Cairo, C.7867) which Andrews had referred to *Mœritherium lyonsi*, type figure Andrews, 1906, Pls. VIII and IX. In 1923 (p. 125) he describes *M. andrewsi* as follows:

SPECIFIC CHARACTERS.—"(3.) Larger form of the Fluvio-marine Formation. Lower premolars not very short in comparison with the length of lower molars; P_{2-4}, 70 (specimen in the American Museum)—73 mm. (Andrews); lower molars rather long: M_{1-3}, 99 (Andrews)—100 mm. (specimen in the American Museum). All the lower cheek-teeth are narrow. P_2, fusiform in upper view, its widest part corresponding to the middle part. P^{2-4}, 70–75 mm. (Andrews); M^{1-3}, yet unknown, but M^{1-2}, ca. 61 mm. (British Museum, cast in the American Museum). Skull large and heavily built. Sagittal crest rather weak. Zygomatic width rather small in comparison with the length of skull. Distance between the two external auditory openings, as well as the width of occiput, small, being smaller even than in the next form [*M. trigodon*]..... *M. andrewsi*."

REFERRED SPECIMENS (Matsumoto, 1923, p. 129).—"[Amer. Mus.] No. 13432; right half of a full-grown skull, without teeth, well preserved in the limit of the parts represented. [Amer. Mus.] No. 13434; right upper tusk, *viz.* I^2, with well-worn crown. Extra

no.; left first upper incisor, with imperfectly preserved crown. [Amer. Mus.] No. 13437, greater part of a mandible, with the right series of cheek-teeth, except P_4 which might have been accidentally lost in the life of the animal, and with left M_{2-3} *in situ*. All from the Fluvio-marine Formation of the Fayûm."

Matsumoto (*op. cit.*, pp. 129,132) observes that while Schlosser's type and the specific name *Mœritherium andrewsi* are valid, Schlosser erred in referring to this species other specimens which belonged to *Mœritherium trigodon*. He gives detailed description and measurements of referred skull (Amer. Mus. 13432) in comparison with *M. trigodon*, as well as detailed comparative measurements with the Andrews-Schlosser type; also characters and measurements of the first upper incisors, I^1, of the second upper incisors, I^2, which constitute the tusks, also of the third upper incisors, I^3, which are rarely found. A referred I^3 has a triangular crown, it measures 14 mm. in length, 8 mm. in width, and 13 mm. in height of crown. All three upper incisors of *Mœritherium andrewsi* appear to have had the crown and root well differentiated. In the lower tusks, I_2, one measures 28 mm. in length of crown, as compared with 38 mm. in length of crown in I^2.

Osborn, 1924: Osborn confirms Matsumoto's reference of this large Fluvio-marine species, and with the coöperation of Doctor Matsumoto restores the skull (Fig. 42) of *Mœritherium andrewsi-trigodon* partly with the aid of *M. lyonsi* materials.

Palæomastodon minus Andrews, 1905 = **Phiomia minor**

Palæomastodon minus Andrews, 1905. "Note on the Species of *Palæomastodon*," Geol. Mag., 1905, Dec. V, N. S., Vol. II, p. 562.

(Andrews, letter, 1922): "This was only a slip, later in the same paper *P. minor* was used."

Palæomastodon intermedius Matsumoto, 1922

Figures 38, 39, 49, 88, 91-94, 300; see also page 146

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

Palæomastodon intermedius Matsumoto, 1922. "Revision of *Palæomastodon* and *Mœritherium*. *Palæomastodon intermedius*, and *Phiomia osborni*, New Species," Amer. Mus. Novitates No. 51, November 21, 1922, pp 1–6. TYPE.—(*Op. cit.*, p. 2): . . . "fragment of left mandibular ramus bearing all three molars *in situ*, with parts of alveoli of penultimate and last premolars." Amer. Mus. 14547. Paratypes: Amer. Mus. 13480, "a fragment of left mandibular ramus bearing last molar and posterior root of penultimate molar *in situ*." Amer. Mus. 13449, palate. Amer. Mus. 14548, maxilla, P^3-M^2. HORIZON AND LOCALITY.—Fluvio-marine formation (Lower Oligocene), north of Lake Qurun, Fayûm, Egypt. Paratypes: Amer. Mus. 13480, southwest of Quarry B; Amer. Mus. 13449, Quarry A; Amer. Mus. 14548, north of Lake Qurun. TYPE FIGURE.—*Op. cit.*, p. 2, fig. 1.

TYPE DESCRIPTION.—Matsumoto's original description is as follows (*op. cit.*, 1922, p. 2):

"*Palæomastodon intermedius*, new species. TYPE: American Museum No. 14547; fragment of left mandibular ramus, bearing all three molars *in situ*, with parts of alveoli of penultimate and last premolars."

"Paratype: American Museum No. 13480; a fragment of left mandibular ramus bearing last molar and posterior root of penultimate molar *in situ*."

"American Museum referred [paratype] specimens: Nos. 13449, 14548."

"All from Fluvio-marine formation."

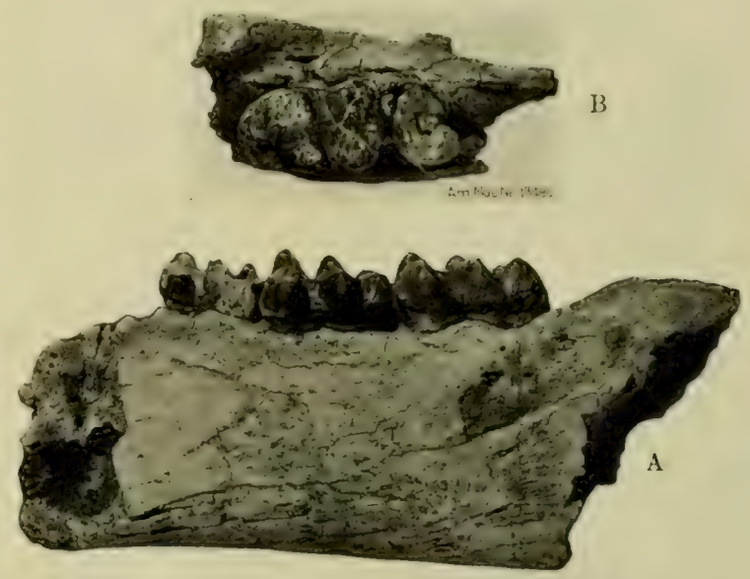


Fig. 38. *Palæomastodon intermedius* Matsumoto, 1922. Type and paratype specimens. After Matsumoto, 1922, p. 2, fig. 1, p. 3, fig. 2. A, Type specimen, fragment of left mandibular ramus (Amer. Mus. 14547). One-third natural size. External view. B, Paratype specimen, fragment of left mandibular ramus (Amer. Mus. 13480). One-third natural size. Superior view.

"The palate of paratype specimen of *Palæomastodon intermedius*, No. 13499 [13449], measures as follows:"

Length from the frontal plane tangential to the anterior limits of the crowns of the two P^2 to the tip of the posteriorly directed process at the posterior limit of the median suture between the two palatines	250 mm.
Distance between the two P^2	53 mm.
Distance between the two M^1	77 mm.
Distance between the two M^3	75 mm."

"All the upper molars are distinctly bilophodont, as a generic character, the rudiment of the third ridge being much feebler and much less conspicuous than that of the lower molars. The mode of wearing corresponds well to what is stated of the lower molars. Besides, all the generic characters of all the cheek teeth of this species are the same as those stated in the diagnosis of the genus."

CHARACTERS OF PALÆOMASTODON INTERMEDIUS (MATSUMOTO, 1924.1, P. 10).—In this Bulletin *Palæomastodon intermedius* is described and measured in great detail from four specimens. (1)

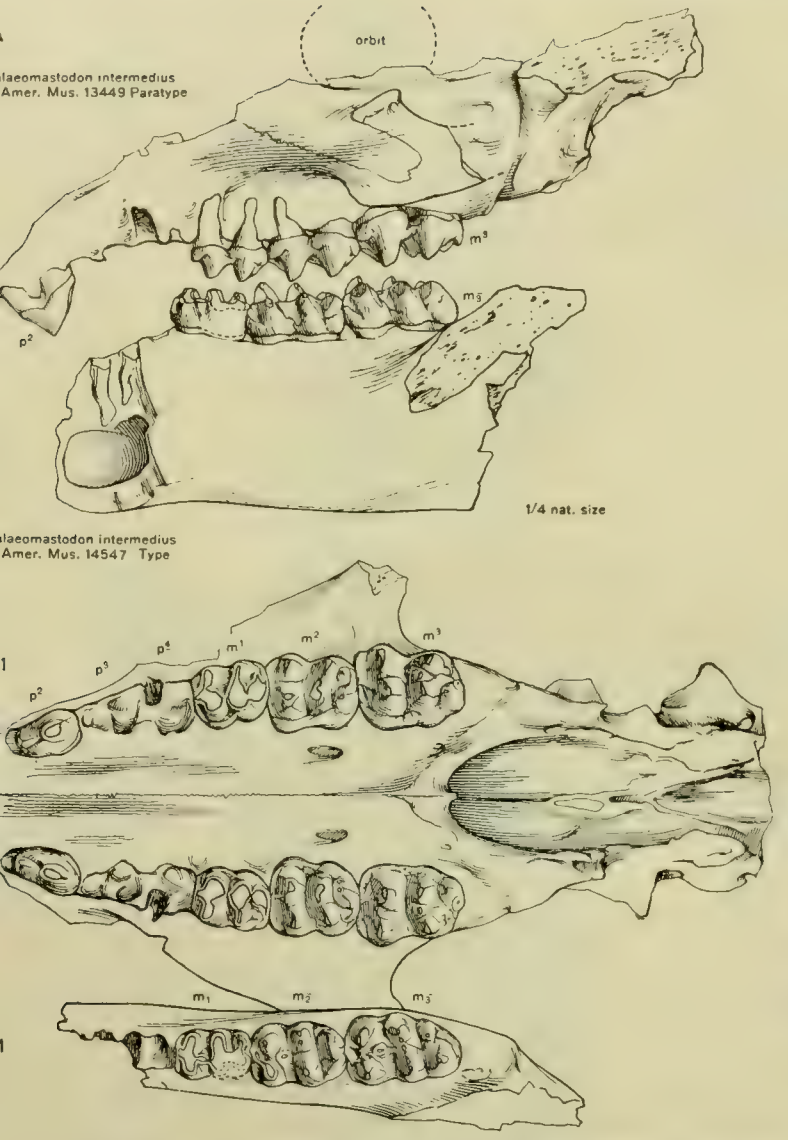


Fig. 39. Type jaw and paratype skull of *Palæomastodon intermedius* Matsumoto assembled and refigured in lateral view. One-fourth natural size.

B, B1, Type jaw of *P. intermedius* (Amer. Mus. 14547). The cavity may represent a hollow space within the jaw or a continuation of the alveoli of the lower incisors. B1, Crown view of same type jaw.

A, A1, Paratype skull fragment of *P. intermedius* (Amer. Mus. 13449), lateral view. A1, palatal view of same specimen.

Compare figure 93 of Chapter VI, enlarged diagram of hexabunodont third superior and inferior molars.

The type (Amer. Mus. 14547); the paratypes (Amer. Mus. 13480), a fragment of left mandibular ramus from near Quarry B, also "Quarry B [A]. . . [Amer. Mus.] No. 13449; a large fragment of skull consisting chiefly of the palate, bearing anterior premolars (P^2) and all molars of both sides *in situ*, and with alveoli of penultimate and last premolars of both sides; Amer. Mus. Exp. 1907. [Amer. Mus.] No. 14548; a fragment of skull and palate, bearing penultimate premolar to penultimate molar of left side *in situ*; purchase, 1909. All the specimens, Fluvio-marine formation of the Fayûm, Egypt." (2) "In all the lower molars [M_{1-3}] the third ridge is rather poorly developed, being distinctly narrower than the first and second ridges; the posterior valley is distinctly narrower antero-posteriorly and shallower than the anterior valley; so that the third ridge looks simply like a talon. As a generic character, the very bottoms as well as the walls of the valleys were worn, even in the very earlier stages of wearing." (3) "All the upper molars are distinctly bilophodont, as a generic character, the rudiment of the third ridge being much feebler and much less conspicuous than that of the lower molars. The mode of wearing corresponds well to what is stated of the lower molars. Besides, all the generic characters of all the cheek teeth of this species are the same as those stated in the diagnosis of the genus."

Phiomia osborni Matsumoto, 1922

Figures 2, 17, 40, 41, 41a, 90, 171, 185, 185a, 187, 222, 258, 283, 286, 300, 316, 430; see also page 244

Fluvio-marine formation, eight miles west of Quarry A, Alexandria Trail, Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

Phiomia osborni Matsumoto, 1922. "Revision of *Palæomastodon* and *Mœritherium*. *Palæomastodon intermedius*, and *Phiomia osborni*, New Species," Amer. Mus. Novitates No. 51, November 21, 1922, pp. 1–6. TYPE.—(*Op. cit.*, p. 3): . . . "a nearly complete mandible, bearing all the teeth *in situ*." Amer. Mus. 13468. TYPE LOCALITY.—Eight miles west of Quarry A, Alexandria Trail, Fayûm, Egypt. TYPE FIGURE.—*Op. cit.*, p. 4, fig. 3.

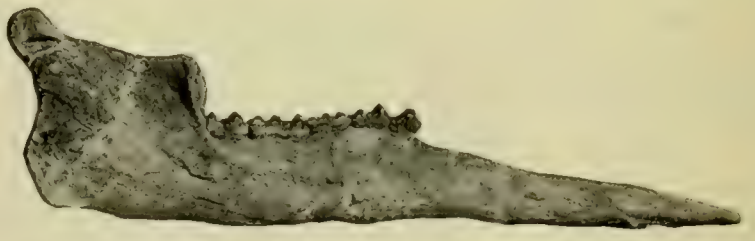


Fig. 40. Original type figure of *Phiomia osborni* Matsumoto, 1922. After Matsumoto, 1922, fig. 3. Type specimen, mandible (Amer. Mus. 13468). One-seventh natural size. Lateral view, right side.

TYPE DESCRIPTION.—Matsumoto's original description (1922, p. 5) is as follows: "This species, *Phiomia osborni*, appears to be more progressive than *Phiomia minor* and *Phiomia wintoni* in the better developed posterior ridge of the first and second lower molars and in the better developed posterior talon of the last lower molar; and to be more archetypal than the same in the more gradual increase in size posteriorly of the lower cheek teeth."

CHARACTERS OF PHIOMIA OSBORNI (MATSUMOTO, 1924.1, pp. 40–49).—The type (Amer. Mus. 13468) is regarded as a male and detailed measurements of mandible and teeth are given in comparison with a *supposed female* of *Phiomia wintoni* (Amer. Mus. 13476). (1) Judging from the large last molars, M_3, as well as from the large symphyseal region and tusks, this mandible is regarded as a male with the following principal measurements:

Length from tip of symphysis to posterior side of angle	640 mm.
Length of symphysis	275 "
Length of premolar-molar series	250–255 "
Length of true molar series	177–180 "

(2) The cheek teeth occupy relatively more space than in the supposed female of *P. wintoni* (Amer. Mus. 13476); mandible shorter behind symphysis than in *P. wintoni* female (Amer. Mus. 13476), see also Andrews, 1906, text figure 54 of *P. wintoni*. (3) Thus this supposed male type of *P. osborni* appears to have a shorter jaw behind the mandibular symphysis than the supposed female of *P. wintoni;* this indicates a post-symphyseal reduction of the jaw in *P. osborni*. (4) The left and right lower tusks protrude 58 mm. and 83 mm. respectively from the jaw; each has a distinct notch at the tips which may be the result of wear in digging and uprooting plants. (5) Symphysis extends back as far as the middle part of P_3. (6) Lower premolars comparatively large and elongate. (7) The last lower molar, M_3, extremely elongate and comparatively narrow although not beyond the limit of variation of M_3 in *P. wintoni*. (8) Posterior cheek teeth, M_{1-3}, increasing in size more gradually than in *P. wintoni*; posterior lobe of P_4 distinctly wider than anterior lobe; differences of proportion are observed in the premolar teeth in both *P. minor* and *P. wintoni*. (9) Posterior talon of M_3 constitutes an imperfect fourth lobe consisting of two prominent cusps, besides a few smaller cuspules, an important progressive character. (10) Basal cingula of all molars very strong. (11) Intermediate cusps (trefoils) well developed.

Summary (Matsumoto).—This species appears to be more progressive than *P. minor* and *P. wintoni* in the more strongly developed posterior ridge of the first and second lower molars, M_{1-2}, and in the better developed posterior talon of the last lower molar, M_3; and to be more primitive than the same in the more gradual increase in size posteriorly of the lower cheek teeth, M_{1-3}. Nothing is yet known about the skull and upper teeth; it is of course possible that some of the fragments of the skulls and some of the upper teeth referred to *P. wintoni* may really belong to *P. osborni*, although it is impossible at present to be certain of this.

Osborn, 1924: Osborn confirms Matsumoto's separation of this animal and adds drawings and diagrams showing its distinctness from *Palæomastodon beadnelli* and also illustrating the progressively distinct *trilophodont* structure of M_1 and M_2 and the *tetralophodont* structure of M_3.

Mœritherium ancestrale Petronievics, 1923

Figure 47; see also page 76

Qasr-el-Sagha(?) formation of the Fayûm, Egypt = Middle Eocene of Andrews = Upper Eocene of the present Memoir.

A full account and figure of this recently described species of *Mœritherium* are given in Chapter III of the present Memoir.

SYNOPSIS OF SPECIES IN ORDER OF PHYLOGENY AND THEIR PRESENT REFERENCE

Lower Oligocene Fluvio-marine Beds

	Reference in Present Memoir	Original Reference
MASTODONTIDÆ	*Palæomastodon beadnelli*	*Palæomastodon beadnelli*
	Palæomastodon intermedius	*Palæomastodon intermedius*
	Palæomastodon parvus	*Palæomastodon parvus*
BUNOMASTODONTIDÆ	*Phiomia barroisi*	*Paleomastodon barroisi*
	Phiomia osborni	*Phiomia osborni*
	Phiomia serridens	*Phiomia serridens*
	Phiomia wintoni	*Palæomastodon wintoni*
	Phiomia minor	*Palæomastodon minor*
MŒRITHERIIDÆ	*Mœritherium trigodon*	*Mœritherium trigodon*
	Mœritherium andrewsi	*Mœritherium andrewsi*

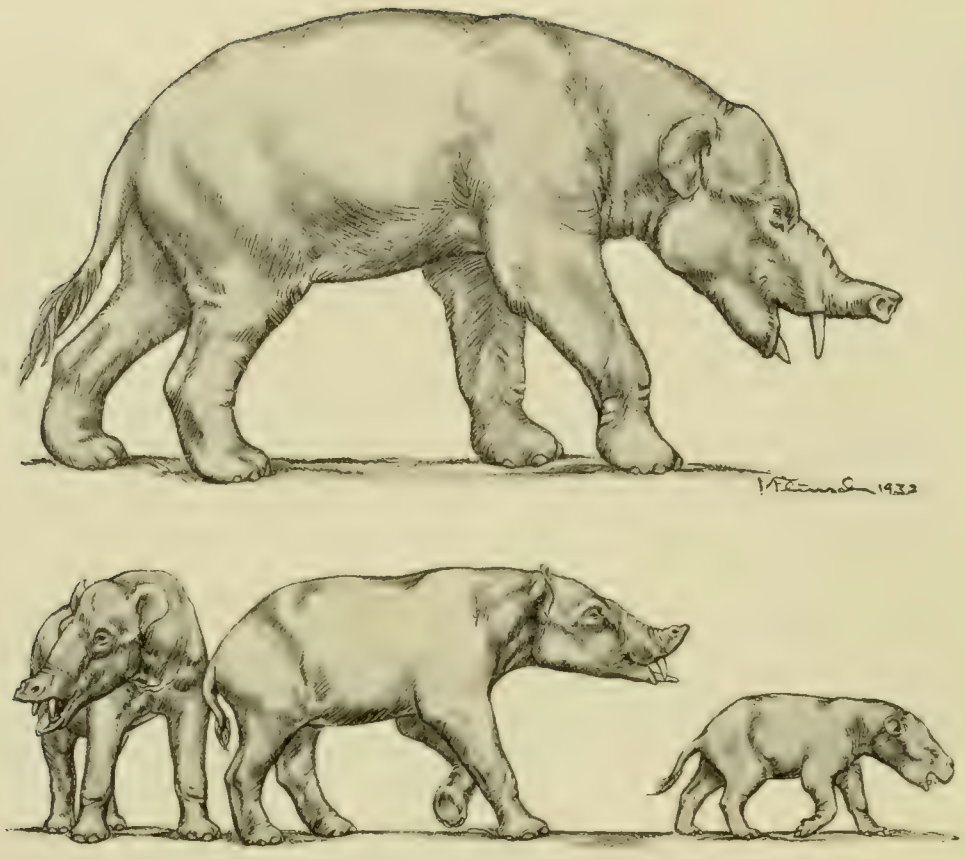
Upper Eocene Qasr-el-Sagha Beds

MŒRITHERIIDÆ	*Mœritherium lyonsi*	*Mœritherium lyonsi*
	Mœritherium gracile	*Mœritherium gracile*
	Mœritherium ancestrale	*Mœritherium ancestrale*

According to their present reference these Fayûm species, treated in chronological order of description above, will be treated in subsequent chapters in the order of their relationships and phylogenetic succession, as follows:

Phiomia: Fam. BUNOMASTODONTIDÆ, Subfam. Amebelodontinæ (Chapter VIII).
Palæomastodon: Fam. MASTODONTIDÆ, Subfam. nov. Palæomastodontinæ (see Appendix).
Mœritherium: Fam. MŒRITHERIIDÆ, Subfam. Mœritheriinæ (Chapter III).

To the above members of the Bunomastodontidæ should be added the Upper(?) Oligocene species *Phiomia pygmæus* originally described as *Mastodon angustidens* Cuv. mut. asc. *pygmæus* Depéret, 1897, and as occurring in the more recent formation of Kabylie, Algeria.



RESTORATIONS (1932) OF THE PRIMITIVE FAYÛM PROBOSCIDEANS

Uniform reduction to one thirty-sixth natural size

Fig 41. When compared with the imaginary scene (Fig. 2, p. 18) on the 'Ur-Nile' or 'Ancestral-River-Nile' of the Fayûm region of North Africa, these reconstructions are designed to dispel the wholly erroneous notion that *Mœritherium*, *Phiomia*, and *Palæomastodon* are in any way ancestral to each other. On the contrary, their cranial, dental, and skeletal characters show them to be profoundly different and divergent both in habit and habitat. The relative rarity of remains of *Palæomastodon* is consistent with its interpretation as a forest-loving form, in contrast to the more abundantly represented shore-loving *Phiomia* and the still more frequent water-loving *Mœritherium*.

(Upper) *Palæomastodon beadnelli* Andrews, after material described by Andrews, Matsumoto, and Osborn. Cranium, ears, proboscis, and tusks largely conjectural.

(Left lower) *Phiomia osborni* Matsumoto, after cranial and skeletal parts described by Andrews, Matsumoto, and Osborn.

(Right lower) *Mœritherium andrewsi* Schlosser. After materials described by Schlosser, Andrews, and Matsumoto, and cranial reconstruction by Osborn (Fig. 42, p. 68).

Of the three restorations, *Palæomastodon* is the most hypothetical; as shown in the figures of Chapter VI, "The Subfamily Mastodontinæ," besides the skeleton, only the jaw and palate are known, while the upper and lower incisive tusks, cranium and mouth parts, and cranio-aural parts are still unknown. *Phiomia*, on the other hand (as shown in Chap. VIII, pp. 236–247), is relatively well known in its cranial structure. *Mœritherium* is also relatively well known (Chap. III, pp. 67–79) both in cranial and limb structure. The mouth parts and feeding habits of *Phiomia* are deductible from our recent knowledge of its shovel-tusker descendants (*Amebelodon*), as conceived and restored by Osborn and Borissiak.

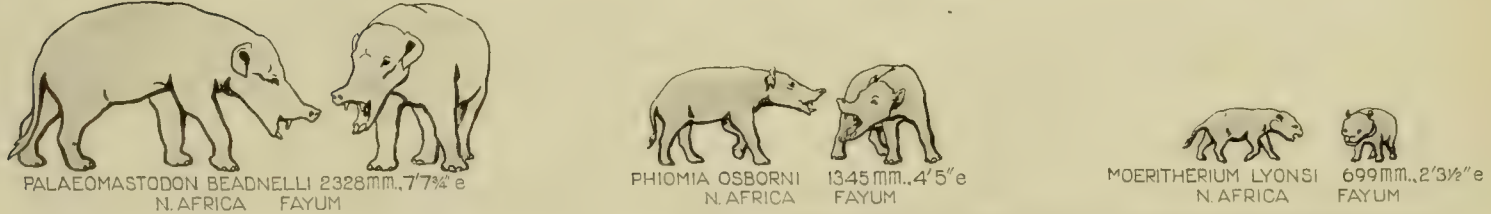


FIG. 41a. RESTORATIONS ONE-HUNDREDTH NATURAL SIZE BY MARGRET FLINSCH, UNDER THE DIRECTION OF HENRY FAIRFIELD OSBORN

Chapter III

THE MŒRITHERES (MŒRITHERIOIDEA) OF NORTH AFRICA IN EOCENE-OLIGOCENE TIME

In the present chapter III is given a detailed systematic revision of the specific types of mœritheres.

See chapter II for (a) separation of the mœritheres from other proboscideans of North Africa, (b) systematic classification of the mœritheres, (c) comparison of mœritherium with phiomia, (d) relations of mœritherium to palæomastodon and phiomia, (e) complete separation of these three genera, (f) phylogenetic relations to other proboscideans, (g) probable amphibious and fluviatile habitat, (h) detailed comparison of the grinding teeth with those of palæomastodon and phiomia, and (i) geologic distribution of mœritherium as compared with phiomia and palæomastodon.

1. Subordinal, family, subfamily, and generic characters. Reconstructions of *Mœritherium* by Osborn.
2. Revised descriptions and definitions of the species of *Mœritherium* in phylogenetic order.

Type and characters of *Mœritherium lyonsi* Andrews, 1901.

Type and characters of *Mœritherium gracile* Andrews, 1902.

Type and characters of *Mœritherium andrewsi* Schlosser, 1911.

Type and characters of *Mœritherium trigodon* Andrews, 1904.

Type and characters of *Mœritherium ancestrale* Petronievics, 1923.

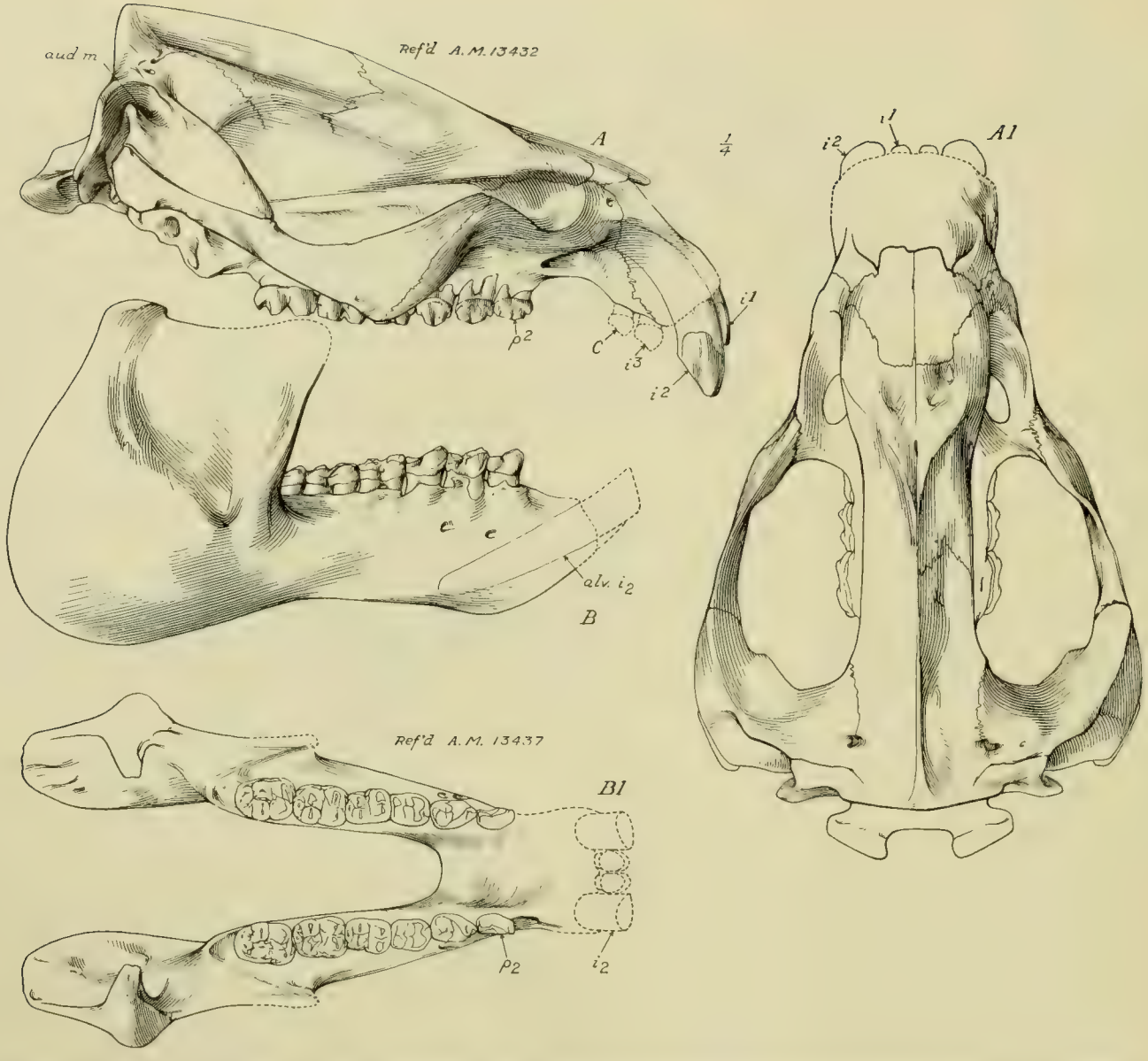
Mœritherium molars compared in detail with those of *Palæomastodon* and *Phiomia*.

Supposed *Mœritherium* of Baluchistan.

1. SUBORDINAL, FAMILY, SUBFAMILY, AND GENERIC CHARACTERS

Mœritherium is very fully treated in the preceding Chapter II, in comparison with the contemporary proboscideans, by a complete review of the opinions and theories of Charles W. Andrews, who first recognized and described the genus (1901–1906) and the majority of the species embraced within it. Also see the opinions and theories of Hikoshichirô Matsumoto and those of the present writer on the habits, habitat, and relationships of this genus, which, while standing apart from and not directly ancestral to any of the other Proboscidea, displays many primitive ancestral characters of the order Proboscidea that are lost in other phyla.

In the present Chapter III it remains to complete the systematic description of the species of this genus, to define clearly the suborder Mœritherioidea and the family characters, to establish the types and type geologic levels of the species, to quote Matsumoto and Petronievics in their detailed studies of the cranial structure of *Mœritherium*, and to make a very detailed comparison of the grinding teeth of *Mœritherium* and of *Palæomastodon*.



OSBORN'S RECONSTRUCTION (1920) OF THE CRANIUM AND JAWS OF MŒRITHERIUM ANDREWSI-TRIGODON TO BE COMPARED WITH ANDREWS' RECONSTRUCTION (1906) OF M. LYONSI (FIG. 18).

Fig. 42. Second reconstruction of the skull of *Mœritherium* (*M. andrewsi*, *M. trigodon*), 1920, which is to be compared with the first reconstruction of *M. lyonsi* by Andrews (Fig. 18).

This reconstruction by Henry Fairfield Osborn with the coöperation of Dr. Hikoshichirô Matsumoto assigns chiefly a gliriform feeding function to the superior and inferior incisor teeth. There is no evidence that the upper incisor teeth were chiefly weapons or tusks, as indicated in the British Museum reconstruction and the model of the skull by Andrews (see Fig. 18).

A, A1, Top and side views of skull chiefly based on Amer. Mus. 13432 (*M. andrewsi*), 13430 (*M. trigodon*).

B, B1, Top and side views of jaw chiefly based on Amer. Mus. 13437 (*M. andrewsi*), 13436, 13435 (*M. trigodon*).

The American Museum specimens were used as follows: For size and general characters No. 13432; for the first incisor No. 13442; for the second incisor No. 13434; the faint lines indicate position of the root of I^2-I_2; for the structure of the grinding teeth Nos. 15898 and 13430; for the structure of the pterygoids and occiput No. 13430.

Fig. 42a. Ancient Mœritheres of northern Africa. One-hundredth natural size. Restorations by Margret Flinsch, under the direction of Henry Fairfield Osborn.

Suborder or Superfamily: I. MŒRITHERIOIDEA Osborn, 1921

Original reference: Amer. Mus. Novitates, No. 1, 1921, p. 2 (Osborn, 1921.515).

Subordinal Characters.—(1) Palustral, amphibious, and semi-aquatic quadrupeds, with ancestral genetic affinities to the Proboscidea in the dentition, and analogies to the Sirenia and Hyracoidea in the skull. (2) Vertebræ estimated: Cervicals 7, dorsals 19–20, lumbars 4, sacrals 4; vertebral structure indicating an ambulatory and amphibious habit (*fide* descriptions of Andrews, 1906, pp. 112–117). (3) Girdles, scapulæ, and pelvis very primitive with analogies to the sirenian type, not expanded as in the proboscidean graviportal type. (4) Proportions of humerus and forearm unknown; humerus distally of primitive locomotor type. Femur with ligamentum teres pit, greater and lesser trochanter, absence of inner trochanter; straight, not unlike Proboscidea. (5) Probably pentadactyl. (6) Cranium primitive, greatly elongated, tubular brain cavity, small brain case of archaic type, zygomatic arches slender. (7) Face abbreviated, orbits small, nasals abbreviated. (8) Somewhat reduced eutherian dentition: $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{3}{3}$, $M\frac{3}{3}$. Second incisors, I^2-I_2, enlarged, curved, gliriform, partly surrounded by enamel. (?) Motion of jaw vertical-orthal.

The subordinal characters are derived from the detailed observations, descriptions, and definitions of Andrews (1906, pp. 99–120), as confirmed by Osborn (1907–1923), and as extended by Matsumoto (1922–1923). The most recent review is that of Petronievics (1923) cited below under the description of *Mœritherium ancestrale*.

The numerous archaic and primitive characters in the trunk and limbs of these animals and the feeble muscular areas of the scapulæ and pelvic girdles appear to indicate that they had never passed through a long period of terrestrial locomotion either mediportal or graviportal, much less cursorial. Until the complete adaptation of the fore and hind limbs and the feet is known we cannot determine how far they were terrestrial or how far amphibious. The girdles and limbs are certainly more aquatic in adaptation than those of the hippopotami. On the other hand, the Mœrithere limbs and girdles are not to be compared for a moment in aquatic adaptation with those of the contemporary sirenians. (See Fig. 43.)

Conclusion as to Habits.—In the absence of a more complete knowledge of the limbs, we may conclude that the Mœritheres were chiefly shore-living or marsh-living animals, amphibious in shallow waters, adapted in dentition to a succulent vegetation which could be seized by the opposing upper and lower tusks and by the broad lips, which are sirenoid and hippopotamoid rather than elephantoid.

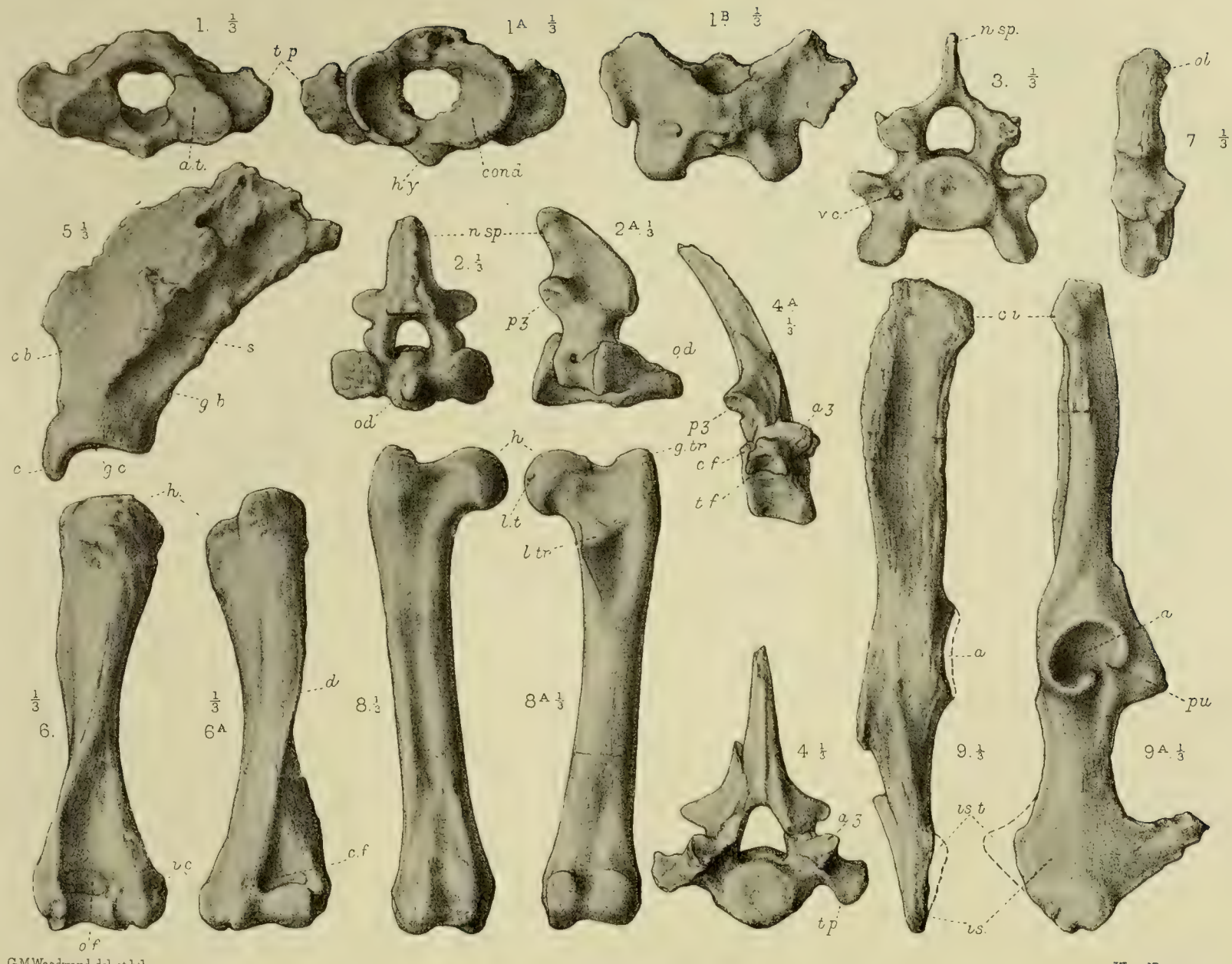
Family: MŒRITHERIIDÆ Andrews, 1906

Original Reference: "A Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt" (Andrews, 1906.1, p. 99).

Definition.—The family Mœritheriidæ Andrews may be redefined as follows: (1) Nares small terminal; (2) orbits opening upwards and outwards; (3) auditory meatus elevated, an aquatic adaptation; (4) superior premolars, P^{3-4}, tritubercular (quadritubercular in *Phiomia* and *Palæomastodon*), premolar tetartocones rudimentary or absent; (5) molars tetrabunodont (quadritubercular), bilophodont, with incipient trilophodonty, quadrate or slightly elongate in proportion; (6) superior molars, M^1 strictly bilophodont, M^2 with rudimentary third crest, M^3 with enlarged third crest; (7) inferior molars, M_2 trilophodont, rudimentary, M_3 trilophodont, trilophodonty not pronounced; (8) all three pairs of premolars and of molars of both jaws functioning at same time; (9) no trace of trefoil pattern or of intermediate conules in any of the *Mœritherium* molars.

Of the eight characters assigned by Andrews (1906, p. 99) to his family Mœritheriidæ, *five* are included above as subordinal characters. We do not agree with Andrews when he remarks: . . . "probably a small proboscis was present," because the structure of the muzzle proves that the animal had a square upper lip.

The family Mœritheriidæ stands well apart in its dental adaptations from its contemporaries, either *Palæomastodon* or *Phiomia*. The food was seized by the gliriform incisors and there was an up-and-down or chopping motion (vertical-orthal) of the bilophodont, subtrilophodont grinders, as compared with the lateral grinding



G.M.Woodward del. et lith

West, Newman imp.

MŒRITHERIUM LYONSI.

AXIAL AND APPENDICULAR SKELETON OF MŒRITHERIUM LYONSI. AFTER ANDREWS

Fig. 43. Facsimile reproduction after Andrews, 1906, Pl. XI, figs. 1–9, all one-third natural size. Nine different individuals.

(1, 1A, 1B) Atlas, anterior, posterior, and dorsal.
(2, 2A) Axis, anterior and lateral.
(3) Cervical 6, posterior.
(4, 4A) Dorsal associated with type mandible.
(5) Left scapula.
(6, 6A) Left humerus.
(7) Ulna, proximal.
(8, 8A) Right femur.
(9, 9A) Right innominate bone.

motion of the molars in *Palæomastodon* and in *Phiomia*. The delicate zygomatic arches indicate feeble development of the masseter and temporal muscles.

These family characters probably represent the climax in a long period of evolution. Close comparison of the grinding teeth of *Mœritherium* (Fig. 49A, B, C) with those of *Palæomastodon intermedius* (Fig. 49D, E) indicates that they are tetrabunodont and sublophodont, and it also shows that *Mœritherium* differs from *Palæomastodon* in the total absence of any trace of the 'central conules' in the molars.

Subfamily: Mœritheriini Winge, 1906; Mœritheriinæ Osborn, 1923

Original reference: "Jordfundne og nulevende Hovdyr (Ungulata) fra Lagoa Santa, Minas Geraes, Brasilien." E. Museo Lundii, 1906, III, p. 172 (Winge, 1906.1); also Amer. Mus. Novitates, No. 99, 1923, p. 1 (Osborn, 1923.601).

Subfamily Characters.—(1) First superior and inferior incisors, I^1-I_1, partly functional. (2) Second superior and inferior incisors, I^2-I_2, greatly enlarged. (3) Third superior incisors, I^3, and superior canines, C, greatly reduced. (4) Third inferior incisors, I_3, and inferior canines, C, entirely wanting. (5) Inferior molars, $M_{1\text{-}3}$, elongated, with rudimentary third lobe (*tritolophid*) behind the *protolophid* and *metalophid*. (6) Incisors sheathed in enamel.

Winge's definition of the subfamily Mœritheriini, which he included within the family Elephantidæ, corresponds with Osborn's redefinition of the family Mœritheriidæ above. Inasmuch as *Mœritherium* in its five included species, *M. lyonsi*, *M. gracile*, *M. trigodon*, *M. andrewsi*, and *M. ancestrale*, are the only Mœritheres known, the definition of this subfamily is merely a formal matter.

It is not unlikely that other subfamilies of Mœritheriidæ will be discovered, especially if the Mœritheres should be traced into southern Asia, as suggested by Pilgrim, and should be found in other parts of the African continent.

Genus: **MŒRITHERIUM** Andrews, 1901–1906

Original reference: Tageblatt des V Internat. Zool.-Cong., Berlin, No. 6, Aug. 16, p. 4 (Andrews, 1901.2). (Published Volume Verhandlungen, 1902, p. 528.)

Genotypic species: *Mœritherium lyonsi*.

Generic Characters.—(Andrews, 1906, p. 99): Dental formula:—$i.\frac{2}{2}$; $c.\frac{1}{0}$; $pm.\frac{3}{3}$; $m.\frac{3}{3}$. The second incisors in both jaws greatly enlarged and tusklike. The last premolar not bilophodont; molars bilophodont. This genus is represented by several species, of which *Mœritherium lyonsi* is the type. It is found in both the Middle and Upper Eocene deposits of the Fayûm [=Upper Eocene and Lower Oligocene of the present Memoir].

Matsumoto, 1923, p. 121.—After very detailed comparisons, not summed up in a generic definition, Matsumoto reaches the following conclusion: "I.—Natural Position of Mœritherium. It may be evident from the preceding statements that *Mœritherium* differs strongly from either the hyracoids or the sirenians in many characters, on the one hand, and has many proboscidean and pre-palæomastodont characters on the other hand. If much weight should be given to the sirenian resemblances of *Mœritherium*, then more weight should be given to its hyracoid resemblances. In my opinion *Mœritherium* is to be treated as a very archetypal member of the proboscideans as correctly stated by Andrews at the first." Also: (1) Skull short in comparison with zygomatic width; (2) long nasofronto-parietal region in proportion to length of skull; (3) zygomatic arches relatively long; (4) sagittal and lambdoidal crests well developed; (5) orbits situated just above $P^{2\text{-}3}$ in *Mœritherium*, just above $M^{1\text{-}2}$ in *Palæomastodon;* (6) mandible relatively short; (7) diastemata relatively short; (8) ascending bars of mandible incline slightly forwards; (9) lower border of mandible ascending; (10) symphysis of mandible rather short; (11) upper [and lower] tusks short in comparison with those of the other proboscideans; (12) premolars large in proportion to the molars, the series of cheek teeth increasing gradually in size backwards; (13) ridge formula simpler than in *Palæomastodon*, much simpler than in *Phiomia;* (14) *Mœritherium* structurally a pre-palæomastodont type, that is, *Mœritherium* stands structurally as more primitive than *Palæomastodon* in twenty-three characters which are peculiar to it and also which indicate its remote relationship to *Palæomastodon*.

2. REVISED DESCRIPTIONS AND DEFINITIONS OF THE SPECIES OF MŒRITHERIUM IN PHYLOGENETIC ORDER

Compare original descriptions of the same species in Chapter II, wherein the *chronological order of description* is clearly set forth. Consequently the reader is referred to both Chapters II and III and to the more recent paper of Petronievics for our present knowledge of the species of the genus *Mœritherium*.

Mœritherium lyonsi Andrews, 1901

See Chap. II, p. 54

Qasr-el-Sagha formation of the Fayûm, Egypt = Middle Eocene of Andrews = Upper Eocene of the present Memoir.

The establishment of this species by Andrews and its description, based on forty-six specimens contained in the British and Cairo museums from the Qasr-el-Sagha beds and one specimen in the American Museum collection, are in part set forth in the systematic revision of this Memoir above, pages 54, 55.

SPECIFIC CHARACTERS.—(Matsumoto, 1923, p. 124): "(1.) Larger form of the Qasr-el-Sagha Formation. Lower premolars very short: P^{2-4} [P_{2-4}], ca. 69 mm. (Andrews); lower molars very long, M_{1-3}, ca. 104 mm. (Andrews). All the lower cheek-teeth very wide. P_2, triangular, its widest part corresponding to the posterior lobe. P^{2-4}, 67–78 mm.; M^{1-3}, 85 mm. (Andrews).....*M. lyonsi.*"

It is this genotypic species *M. lyonsi* of the Upper Eocene Qasr-el-Sagha formation which furnishes the chief characters of the genus *Mœritherium* as described and figured in great fullness by Andrews (1906, pp. 99–126, Pls. VIII, IX, and X). The detailed measurements and indices of the superior and inferior teeth in comparison with those of *M. gracile*, *M. andrewsi*, and *M. trigodon* are transcribed and estimated from Matsumoto as follows:

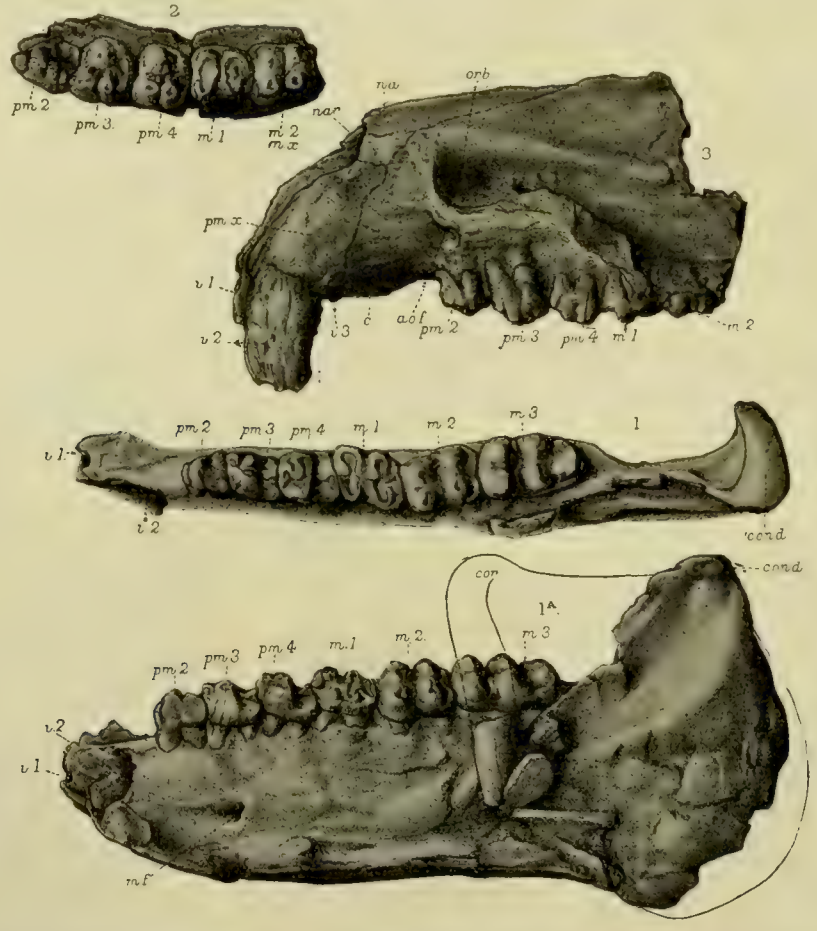


Fig. 44. Second type figure of *Mœritherium lyonsi* Andrews, 1901. After Andrews, 1906, Pl. x, figs. 1, 1A, 2, 3. Geol. Mus., Cairo (C. 10000); cast Amer. Mus. 9977. One-third natural size.

Three individuals: (1, 1A) Type specimen (C. 10000), mandible associated with upper molars and a dorsal vertebra (*op. cit.*, p. 120); (2) "Upper molars and premolars found close to type" (p. 123), of the right side = paratype (C. 10001); (3) front portion of skull, side view (C. 10002, cast Amer. Mus. 9978) = paratype. Same as figure 27.

Lower Teeth	*M. lyonsi*			*M. gracile*			*M. andrewsi*			*M. trigodon*		
	l.	w.	I.	l.	w.	I.	l.	w.	I.	l.	w.	I.
P_2	22	16	73				24–26	11 –14	54	19.5–23	10 –11	48
P_3	23	21	90	22	15	68	27–29	17.5–19	65	22 –25	14? –17	68
P_4	25	23	90	21	18	86	24–25	21	87	22 –25	18 –20	80
M_1	26.5	24.5	92	22–23	19–20	87	28–30	21 –22	73	24 –27.5	19 –21	76
M_2	28 –35	25 –30	86	27–28	22–23	82	32–34	26 –27	79	29 –32	24	83
M_3	39 –42	28 –30	71	33–34	24	72	37–40	26 –28	70	37 –40	24 –26.5	66
P_{2-4}	69+			63+			70–73			63±–70		
M_{1-3}	104+			84			99–100			93 –98		
I_2 width					20+			28			20	
Upper Teeth												
P^2	27	23?	85	22	18	82	25–27	20 –22	81	19 –22?	18? –21	95
P^3	26.5	29.5	111	20	23	115	25–26	28 –32	123	23 –24	24? –26	108
P^4	23	27.5	119	20	21?	105	21–22	27 –29	132	20 –22	23? –25.5	116
M^1	29	27	93	23–25	21–23	92	29–32	25 –27	84	22 –25	24 –26.5	106
M^2	26? –30	23.5–28	93	24–27	23–25	92	32–33	28 –29	88	28 –30	24 –28	93
M^3	32 –37±	28 –30±	81	28	24–25	86				30 –32	26 –27	84
P^{2-4}	67 –68			62			70–75			60 –63		
M^{1-3}	85			75–79±						83 –85		
I^2 width		28						26			21	

American Museum Collection.—Matsumoto refers (1923, p. 125) to the species *Mœritherium lyonsi* two of the three fragments of mandibular rami included in Amer. Mus. 13444; the other fragment of a ramus he refers (*op. cit.*, p. 128) to *M. gracile*, his descriptions being included above in Chapter II, pages 54 and 56 respectively.

Mœritherium gracile Andrews, 1902

See Chap. II, p. 56

Qasr-el-Sagha formation of the Fayûm, Egypt = Middle Eocene of Andrews = Upper Eocene of the present Memoir.

This small form of the Qasr-el-Sagha beds Upper Eocene, is relatively rare, four specimens being described by Andrews from the British and Cairo museum collections while four are described by Matsumoto and Osborn from the American Museum collection.

Specific Characters.—(Andrews, 1906, p. 127): "This species is distinguished from *M. lyonsi* by its comparative lightness of structure, the narrowness of the palate, the smaller size of the upper molars and premolars, particularly of *m.* 3, the strong development of the cingulum in these teeth, and by the considerable inflation of the cranial region of the squamosal, which apparently contains extensive air-sinuses."

(Matsumoto, 1923, p. 125): "(2.) Smaller form of the Qasr-el-Sagha Formation. Lower premolars not very short in comparison with the length of lower molars: P_{2-4}, ca. 62 mm. (specimens in the American Museum); lower molars very short: M_{1-3}, 83 mm. (specimen in the American Museum). All the lower cheek-teeth are narrow. P^{2-4}, 62 mm. (Andrews); M^{1-3}, 75—ca. 79 mm. (Andrews).....*M. gracile*."

Fig. 45. *Mœritherium gracile* and *M. lyonsi* from the Qasr-el-Sagha formation, Upper Eocene of the Fayûm. American Museum collection of 1907. After Matsumoto, 1923, figs. 3 and 4.

Amer. Mus. 13443, *M. gracile;* mandible with P_3-M_3 of the left side and M_{1-3} of the right side *in situ*.

Amer. Mus. 13444, *M. lyonsi;* one of the three fragments of the mandibular rami, with badly preserved molars *in situ*.

Andrews (*op. cit.*, 1906, pp. 127, 128) gives a detailed description with measurements of the four specimens in the British Museum; Matsumoto (*op. cit.*, 1923, p. 128) also gives a detailed description with measurements of the specimens in the American Museum collection. In his comparison of the four species, Matsumoto's detailed dental measurements are as above.

Phylogenetic Summary.—From the limited materials at hand neither Andrews, Matsumoto, nor Osborn has been able to establish the phylogenetic or ancestral relationship of the Qasr-el-Sagha species (*M. lyonsi* and *M. gracile*) to the Lower Oligocene Fluvio-marine species (*M. andrewsi* and *M. trigodon*).

We might suppose that the larger form *M. lyonsi* gave rise to the larger form *M. andrewsi*, but Matsumoto does not believe so. (1) Matsumoto observes that the larger Upper Eocene species *M. lyonsi* seems to be less closely related to its smaller contemporary *M. gracile* than the larger Lower Oligocene form *M. andrewsi* is to the smaller Lower Oligocene form *M. trigodon;* this inference is drawn from the absolute and relative dimensions of the grinding teeth. (2) *M. andrewsi* and *M. trigodon* appear to represent two entirely distinct species and not male and female representatives of the same species, as Schlosser has suggested. (3) So far as can be judged from the relative dimensions of the lower cheek teeth, *M. gracile* appears to be more closely allied to the two geologically succeeding species *M. andrewsi* and *M. trigodon* than to its contemporary *M. lyonsi;* in other words, it appears that *M. gracile* might be the ancestral type of both *M. andrewsi* and *M. trigodon.*

Mœritherium andrewsi Schlosser, 1911

See Chap. II, p. 61

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

This palustral animal, based on specimens referred to *M. lyonsi* by Andrews, occurring in the Fluvio-marine beds with a rich terrestrial fauna, is naturally much less abundant than its predecessors in the Qasr-el-Sagha marine beds; it is represented by twelve specimens in the British Museum (all referred by Andrews to *M. lyonsi*) and by three specimens of *M. andrewsi* in the American Museum, two of which (Amer. Mus. 13432 and 13437) have been largely used in the second reconstruction of the skull of *Mœritherium* shown in figure 42. As set forth in the systematic revision above (p. 61), Schlosser and Matsumoto have clearly separated and defined this larger form as a distinct species, *M. andrewsi,* named in honor of Charles W. Andrews.

Specific Characters.—Matsumoto's characterization (Matsumoto, 1923, p. 125) of this species is cited in full on pages 62, 63 of this Memoir. These characters agree with the reconstruction of the skull by Osborn and Matsumoto shown in figure 42, in which it appears that there are considerable differences in size and proportions between the larger *M. andrewsi* (Fig. 36) and the smaller *M. trigodon* (Fig. 30).

Mœritherium trigodon Andrews, 1904

See Chap. II, p. 57

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

American Museum Collection.—*Mœritherium trigodon* is represented by the single type specimen (Brit. Mus. M. 8499) described by Andrews in 1904, and by six specimens in the American Museum collection, described, figured, and measured by Matsumoto, namely, Amer. Mus. 13430, 13431, 13433, 13435, 13436, 13439.

The cranium is inferior in all its dimensions to the larger and more massive *M. andrewsi* and there appear to be minor differences in the characters of the median and lateral incisors, I^1, I^3. A well-preserved second right upper incisor, I^2, with its casing of enamel (Fig. 42), illustrates the profound difference between the gliriform second superior incisor of *M. andrewsi* and the superior tusk of *Phiomia* (Fig. 183); observe especially the *posterior* surface beveled by the action of the second inferior incisor in contrast to the tusk of *Phiomia* which is worn on the *internal* side. Observe also the profound difference between the lower jaw in superior aspect (Fig. 42) and the lower dentition of *Phiomia* and *Palæomastodon* (Fig. 48) as seen in superior view; also the uniformly worn grinding series, P_2-M_3, of Amer. Mus. 13435 (Fig. 46), as compared with the successional wear in *Phiomia.*

Specific Characters.—(Andrews, 1906, pp. 128, 129—see our Fig. 30): "*Type Specimen.*—Posterior portion of right ramus of mandible (Pl. IX, fig. 5); British Museum. This species is distinguished by the form of the posterior lower molar, which narrows posteriorly, the talon consisting almost entirely of one large tubercle; also by the rapidity with which the teeth decrease in size from behind forwards. . . . This difference in the talons appears to justify the separation of the present form as a distinct species at least, and not improbably further material will show that a new genus must be established. The enamel of the whole tooth is raised into irregular ridges and small tuberosities. The dimensions (in centimetres) of the teeth are:—

	Length.	Width.
m. 1	2.6	?
m. 2	3.2	?
m. 3	4	2.4

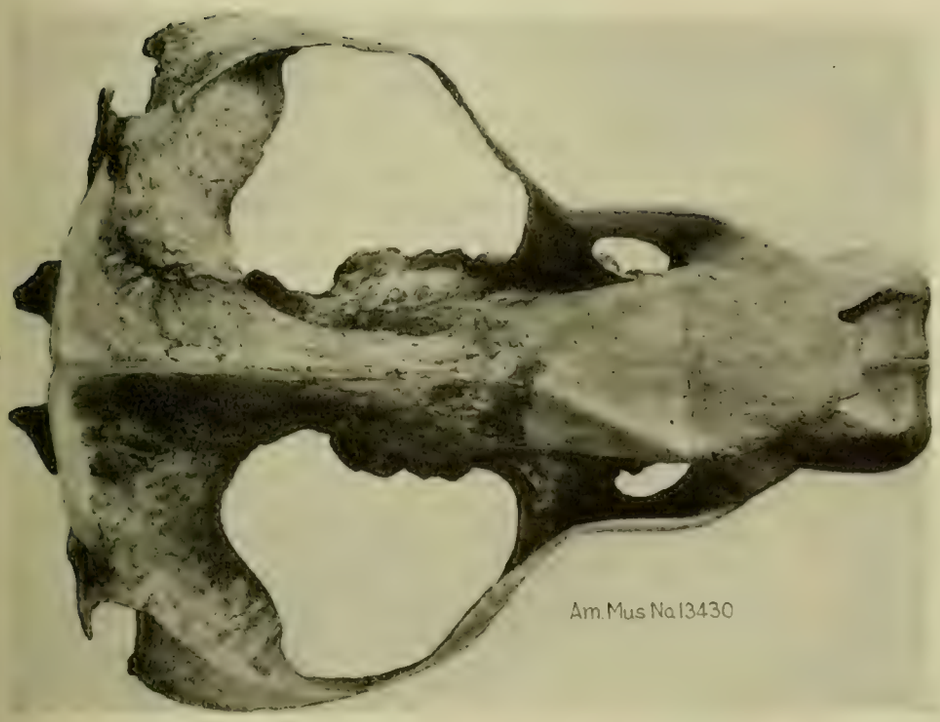
The length of the molar series is 9.8 cm."

Matsumoto's definition (1923, p. 125) is cited above (pp. 57, 58) under the systematic revision. He considers that Andrews lays too much weight on the shape and structure of the talonid or tritolophid of M_3 in distinguishing this species from *M. andrewsi,* remarking that the posterior talon of M_3 appears to be one of the most variable features in the teeth of *Mœritherium,* and that its surface varies according to age and the degree of wearing action of the tooth.

Cranial Characters.—Matsumoto observes (1923, p. 134) in his description of the skull: "The skull of [Amer. Mus.] No. 13430 measures 240 mm. in the length from the point at which the vertical plane tangential to the anterior borders of both P^2 meets the median longitudinal line on the palate, to the basion, 145 mm. in the length from the same point to the median point of the posterior border of palate, about 180 mm. in the length from the anterior limit of the temporal vacuity in palatal view to the posterior lower border of squamosal, 42 mm. in the minimum width of the mid-cranial region (this dimension might be somewhat less than it ought to be in primary condition, as this part of this specimen appears to be crushed secondarily from side to side), 280 mm. in the zygomatic width, about 190 mm. in the distance between the upper borders of external auditory openings (including reliably restored

A

D



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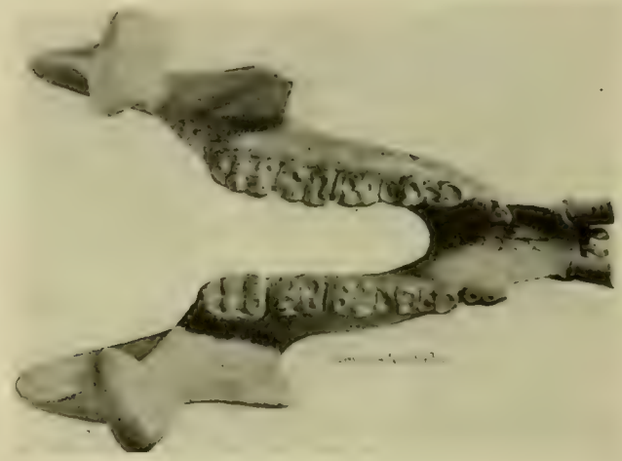

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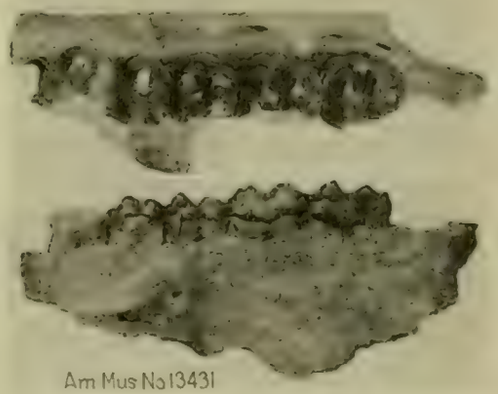

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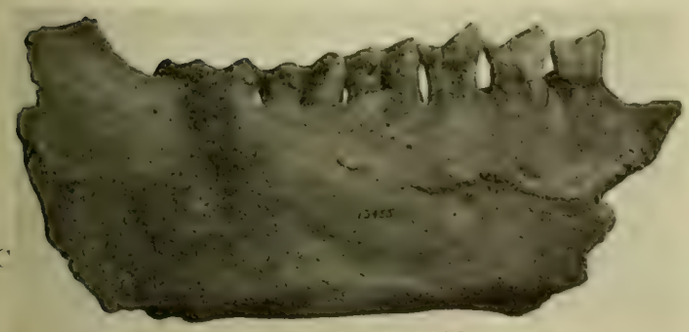


C

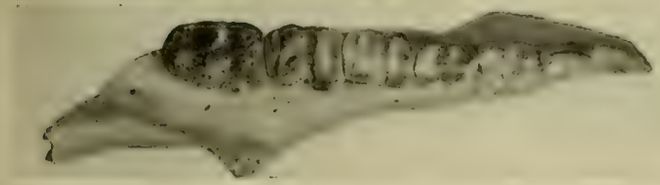


Fig. 46. American Museum Collection of 1907. After Matsumoto, 1923, figs. 1, 2, 6, 7, 8, and 9.

A, B, Amer. Mus. 13430, *M. trigodon*, a full-grown skull, lateral and superior views; partly restored occipital and sagittal crests, nasal and symphyseal region, and anterior teeth. This skull is described and measured in detail by Matsumoto (1923, p. 134) in his description of *M. trigodon*. About one-fourth natural size. (1) Observe the excessively slender, widely arching zygomata, the tubular cranial region, the slender sagittal and lambdoidal crests. (2) Zygomatic width 280 mm.

C, Amer. Mus. 13435, *M. trigodon*, fragment of the right ramus of the mandible, all the cheek teeth, P_2-M_3 *in situ*. One-fourth natural size.

D, Amer. Mus. 13434, *Mœritherium andrewsi* Schlosser, second upper right incisor tooth, I^2; upper, internal view, lower, external view. One-half natural size. Through error this appeared in the original legend (Matsumoto, 1923, p. 126) as *M. lyonsi*.

E, Amer. Mus. 13436, *Mœritherium trigodon*, "ramus of mandible, with all the cheek teeth *in situ*." After Matsumoto, 1923, p. 126, fig. 1, through error referred to *M. lyonsi* in the legend.

F, Amer. Mus. 13431; *M. trigodon*, fragment of skull including greater part of right half of palate bearing P^3-M^3 *in situ*. One-fourth natural size.

parts to a slight extent), 220 mm. in the width of occiput, 91 mm. in the lateral extension of the two occipital condyles, 52 mm. in the width of palate between the two P^2, 34 mm. in the same between the two M^1, and about 150 mm. in the maximum height of the skull, including the upper cheek-teeth (including a restored part of sagittal crest to a slight extent). In this skull the sagittal and occipital crests are extraordinarily well developed; and the occiput is strongly concave, so that its upper half, including the lambdoid crest, inclines distinctly backwards."

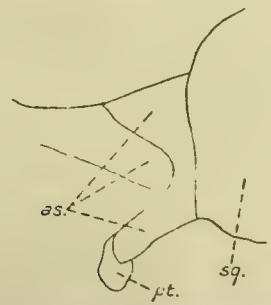
Mœritherium ancestrale Petronievics, 1923

Qasr-el-Sagha(?) formation of the Fayûm, Egypt = Middle Eocene of Andrews = Upper Eocene of the present Memoir.

Mœritherium ancestrale is regarded by Petronievics as nearer to *Palæomastodon* than any previously described species of *Mœritherium*.

Mœritherium ancestrale Petronievics, 1923. "Remarks upon the Skulls of *Mœritherium* and *Palæomastodon*," Ann. Mag. Nat. Hist., Vol. XII (9), pp. 55–61. TYPE.—Skull and mandible (Brit. Mus. M. 9225). HORIZON AND LOCALITY.—Fayûm district of Egypt, Qasr-el-Sagha (?) formation = Middle Eocene of Andrews = Upper Eocene of the present Memoir. TYPE FIGURE.—Petronievics, 1923, p. 56, fig. 1.

Fig. 1.



Part of the left side of the skull of *Mœritherium ancestrale*, ½ nat. size. *as.*, alisphenoid; *pt.*, pterygoid; *sq.*, squamosal.

TYPE OF MŒRITHERIUM ANCESTRALE

Fig. 47. Type of *Mœritherium ancestrale* Petronievics, 1923, p. 56, fig. 1. Reproduced same size as the author's original figure and including the author's legend. Brit. Mus. M.9225.

TYPE DESCRIPTION.—(*Op. cit.*, 1923, p. 57): "There are two main characters of our specimen which justify the supposition that it represents a distinct species:—(1) the elongated palatine vacuity between anterior maxillary prolongations forming the inner border of the sockets for the tusks; (2) the backward direction of the occipital plate. As the first of these two characters brings our specimen nearer to *Palæomastodon* than any other, we will give to the new species the name *Mœritherium ancestrale*, sp. n."

The following is a direct quotation, with some omissions, from the description of Doctor Petronievics (*op. cit.*, pp. 55–57):

"[1] There is in the British Museum [M.9225] a skull and mandible of *Mœritherium* not yet described, which is in several respects important for deciding the question of the ancestral relationship of *Mœritherium* to the Proboscidia. This skull was found by Baron Nopcsa several years ago (1905) in Middle Eocene beds in the Fayûm district of Egypt [Footnote: 'Comp. C. W. Andrews, 'A Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt': London, 1906, p. 121 *seq.* (specimen M. 9225 in the British Museum).']. I propose to describe the features of this skull, which either give some supplementary data as to the morphology of the skull of the genus *Mœritherium* or are peculiar to the species. I propose also to give some additional evidence on the skull of *Palæomastodon*. Finally, I will add a list of the resemblances and differences in the skull, mandible, and dentition of the two genera. [2] In the skull in question the basioccipital is separated from the basisphenoid by a suture situated somewhat obliquely on a ridge at the level of the glenoid surface. The suture between basioccipital and exoccipitals is not plain. The exoccipitals with the condyles are as in *Mœritherium lyonsi*. [3] The same is to be said about the supraoccipital bone; but the whole occipital plate in our specimen is directed backwards, while in *Mœritherium lyonsi* it is directed forwards, and the lateral depressions accompanying the median ridge are deeper in our specimen than in the old one. [4] The squamosal and its relation to the parietal and supraoccipital are the same as in *Mœritherium lyonsi*. [5] The jugal seems to be more slender than in the latter. [6] The tympanic in this specimen is better preserved than in the skull of *Mœritherium lyonsi*. [7] The parietals are as in the latter. It is uncertain if they meet the alisphenoids—probably not. [8] The frontals are as in *Mœritherium lyonsi*, with no postorbital process. The exact relation of the frontals to alisphenoids and parietals is uncertain, but they reach the former. [9] The existence of a separate lachrymal cannot be established. [10] While in *Mœritherium lyonsi* the position of the alisphenoid on the side-wall of the skull could not be determined, in our specimen the limit of the alisphenoid in this respect is quite clear (text-fig. 1). Above the alisphenoid canal the alisphenoid forms a triangular bone. The backward side of this triangle is constituted by the suture separating the alisphenoid from the squamosal, while the upperside is marked by a suture separating the alisphenoid from the frontal (perhaps also from the parietal). It is to be remarked that the position of this part of the alisphenoid bone in our specimen is, perhaps, exactly the same as in *Palæomastodon*. [11] As the premaxillæ are crushed in front, their relation to the nasals and maxillæ cannot be made out. [12] The maxillæ are very large and greatly elongated as in *Mœritherium lyonsi;* but, while in this latter there is only a small palatine vacuity between the slightly divergent anterior prolongations of the maxillæ, this vacuity is larger in our specimen, and the anterior prolongations of the maxillæ undoubtedly form part of the inner border of the sockets for the tusks, although they are somewhat crushed anteriorly. In this respect our specimen is nearer to *Palæomastodon* than any other species of *Mœritherium*. *Mœritherium gracile* has these prolongations longer than *Mœritherium lyonsi*, but they do not reach the inner border of the tusks (comp. Andrews, *l. c.* pl. xvii. fig. 1). [13] The exact shape of the pterygoid is not to be established, but it is certain that its vertical plate projects beyond the end of the descending plate of the alisphenoid (fig. 1). [14] The upper teeth are so worn that their exact structure is not to be made out; but they seem to be the same as in *Mœritherium lyonsi*."

The author follows with a very detailed comparison of the cranial characters of the type of *Mœritherium ancestrale* with those of *Palæomastodon beadnelli* and *P. wintoni* Andrews, and concludes (pp. 58, 59): "The ancestry of *Mœritherium* to *Palæomastodon* has become very probable from the new additional features of the skull in the above-described specimen of *Mœritherium*. But, in order to make it possible to judge better on this question [Footnote: 'On this point three main opinions have been advanced:—(1) *Mœritherium* lies in the direct line of ancestry to the later Proboscidea; (2) *Mœritherium* is a primitive offshoot of the Proboscidean stock; and (3) *Mœritherium* is an offshoot of the Sirenian stock allied to Proboscidea. The first opinion has been maintained by Andrews in his first fundamental memoir on the question (comp. C. W. Andrews, 'The Evolution of the Proboscidea,' in Phil. Trans. 1903, p. 101), but later on (comp. his Catalogue, Introduction, p. xvii) he was rather inclined to adopt the second view. The third opinion was expressed for the first time by H. F. Osborn (in his article 'The Feeding-habits of *Mœritherium* and *Palæomastodon*,' in Nature, July 29, 1909), but abandoned (comp. his work 'The Age of Mammals,' 1910, p. 203 *seq.*) after the vigorous refutation of Andrews (in his article 'The Systematic Position of *Mœritherium*,' in Nature, Sept. 9, 1909). In a recent paper, however, the eminent American palæontologist seems to have returned to his former wrong opinion on the subject (comp. H. F. Osborn, '*Palæomastodon*, the Ancestor of the Long-jawed Mastodons only,' in Proc. Nat. Acad. Sci. vol. v. 1919, pp. 265–266).'], we give here a list of the resemblances and differences in the skull, mandible, and dentition of the two genera [Footnote: 'A similar but much shorter list is to be found in W. K. Gregory, The Orders of Mammals, 1910, p. 367 *seq.*'], which are mainly founded on the characters of *Mœritherium ancestrale* on the one hand, and of *Palæomastodon wintoni* on the other."

Osborn, 1925: In Chapter II of the present Memoir many reasons are given by both Matsumoto and Osborn why we should exclude *Mœritherium* entirely from the ancestry of *Palæomastodon*.

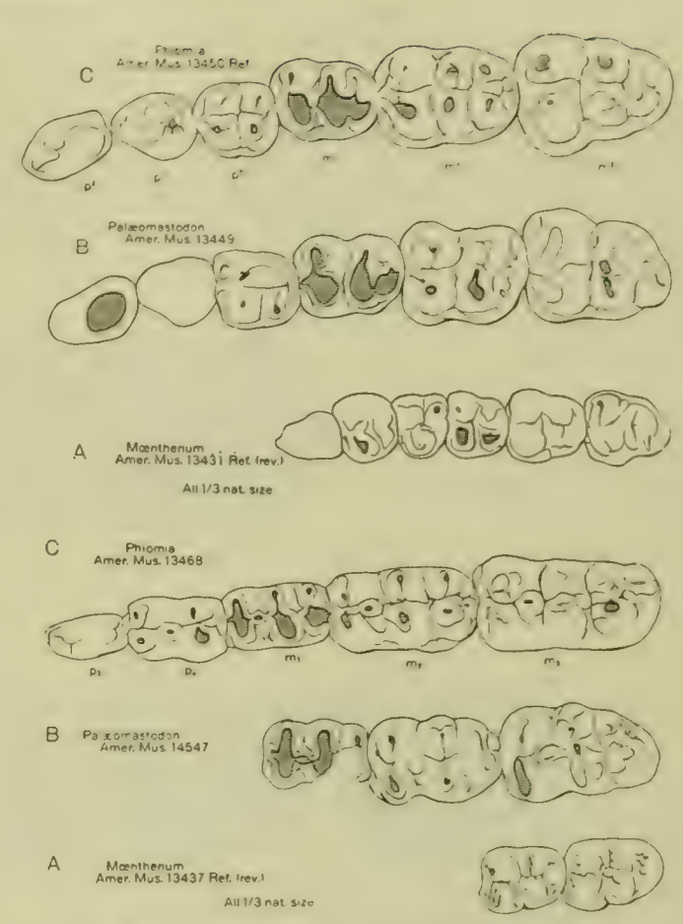


Fig. 48. Comparison of upper and lower molars to the same scale of:

A, True *Mœritherium*, (lower) Amer. Mus. 13437, (upper) Amer. Mus. 13431.

B, True *Palæomastodon*, (lower) Amer. Mus. 14547, (upper) Amer. Mus. 13449.

C, True *Phiomia*, (lower) Amer. Mus. 13468, (upper) Amer. Mus. 13450.

MŒRITHERIUM MOLARS COMPARED WITH THOSE OF PALÆOMASTODON AND PHIOMIA

Figures 42, 45, 46, 48, 49

The five new figures and reconstructions of the grinding teeth assembled in the present Memoir, namely, figure 48, a comparison of the grinding teeth of three genera, figure 45, a comparison of *Mœritherium lyonsi* and *M. gracile*, figure 46, a comparison of *M. trigodon* and *M. andrewsi*, figure 42, second reconstruction of the skull of *Mœritherium andrewsi* and *M. trigodon*, and figure 49, life-size detailed studies of *Mœritherium* and *Palæomastodon* grinding teeth, exhibit very clearly the fundamental resemblances and the progressive differences between the dental and cranial structure of these three Fayûm genera. Figure 49 beautifully displays the superior grinders of *Mœritherium trigodon* in contrast with those of *Palæomastodon intermedius*, demonstrating that *Palæomastodon* cannot in any way be considered as a descendant of *Mœritherium*.

(1) In both *Mœritherium* and *Palæomastodon* M_3 is trilophodont (Fig. 49C, E); (2) in both *Mœritherium* and *Palæomastodon* the second and third superior molars, M^{2-3}, are in an incipient bilophodont condition; (3) in *Palæomastodon* M_{1-2} have a rudiment of a tritolophid not observed in *Mœritherium;* (4) *Palæomastodon* is hexabunodont or sexitubercular, conules persisting in M^{2-3}, while *Mœritherium* is tetrabunodont or quadritubercular, the conules having disappeared; (5) the inner and outer cones are united (Fig. 49D, E) by a transverse crest in *Palæomastodon*, M^{2-3}, M_{2-3}; they are separated by a longitudinal cleft in *Mœritherium*. (6) As to adaptation, this demonstrates that *Mœritherium* had more of the omnivorous, chœrodont habit, while *Palæomastodon* had more of the browsing, lophodont habit. The evolution of the *Palæomastodon* molars is discussed in full below under *Palæomastodon* (Chap. VI).

Conclusion.—This detailed comparison serves to demonstrate that both *Mœritherium* and *Palæomastodon* may have descended from an original primary tetrabunodont stock; that the intermediate tubercles or 'central conules' never developed (Fig. 37) in *Mœritherium*, while they did develop in *Palæomastodon intermedius*, M^{2-3}, M_{2-3}. These conules, moreover, are in process of development in *Palæomastodon*, the lophs being composed of six cones (Figs. 93, 94).

SUPPOSED MŒRITHERIUM OF BALUCHISTAN (Fig. 50)

In 1912 Pilgrim erroneously referred to *Mœritherium* a fragmentary tooth (Ind. Mus. A 452) contained within "The Vertebrate Fauna of the Gaj Series in the Bugti Hills and the Punjab," found near Khajuri, Bugti Hills, Baluchistan, which he described as follows (p. 15): "Mœritherium (?), sp. Plate III, fig. 3. Amongst the Bugti specimens is . . . a fragmentary tooth, possessing characters which lead one, with no uncertainty, to diagnose it as Proboscidean. Although only three quarters of it remain there is no doubt as to its being a rectangular, oblong tooth, possessing two transverse crests, separated by a broad straight transverse valley. Each crest consists of an inner and outer pointed cusp, perfectly distinct from one another. The presumed postero-internal cusp is continued into a small hinder lobe. A beaded cingulum is well developed on that side of the tooth, whose preservation is such, as to render it possible to recognize its presence. The incompleteness of the transverse crests entirely precludes the possibility of its belonging to *Dinotherium*. It is clearly distinguished from premolars of *Tetrabelodon*, not only by the rectangular instead of rounded corners, but also by the perfectly symmetrical arrangement of the cusps, and the breadth and absolutely transverse situation of the valley between the crests. The surface of the enamel also possesses irregular striæ, which are not seen in *Tetrabelodon*. In all these particulars, it agrees exactly with the hinder upper molars of *Mœritherium lyonsi*, Andrews. It is, however, rather larger than this species, and the relative height of the cusps differs. It is by no means unlikely that further material of the Bugti species will show that it belongs to a different genus from *Mœritherium*. At present its interest lies in the proof it affords of the existence in Baluchistan in Gaj times of a primitive Proboscidean allied to *Mœritherium*.

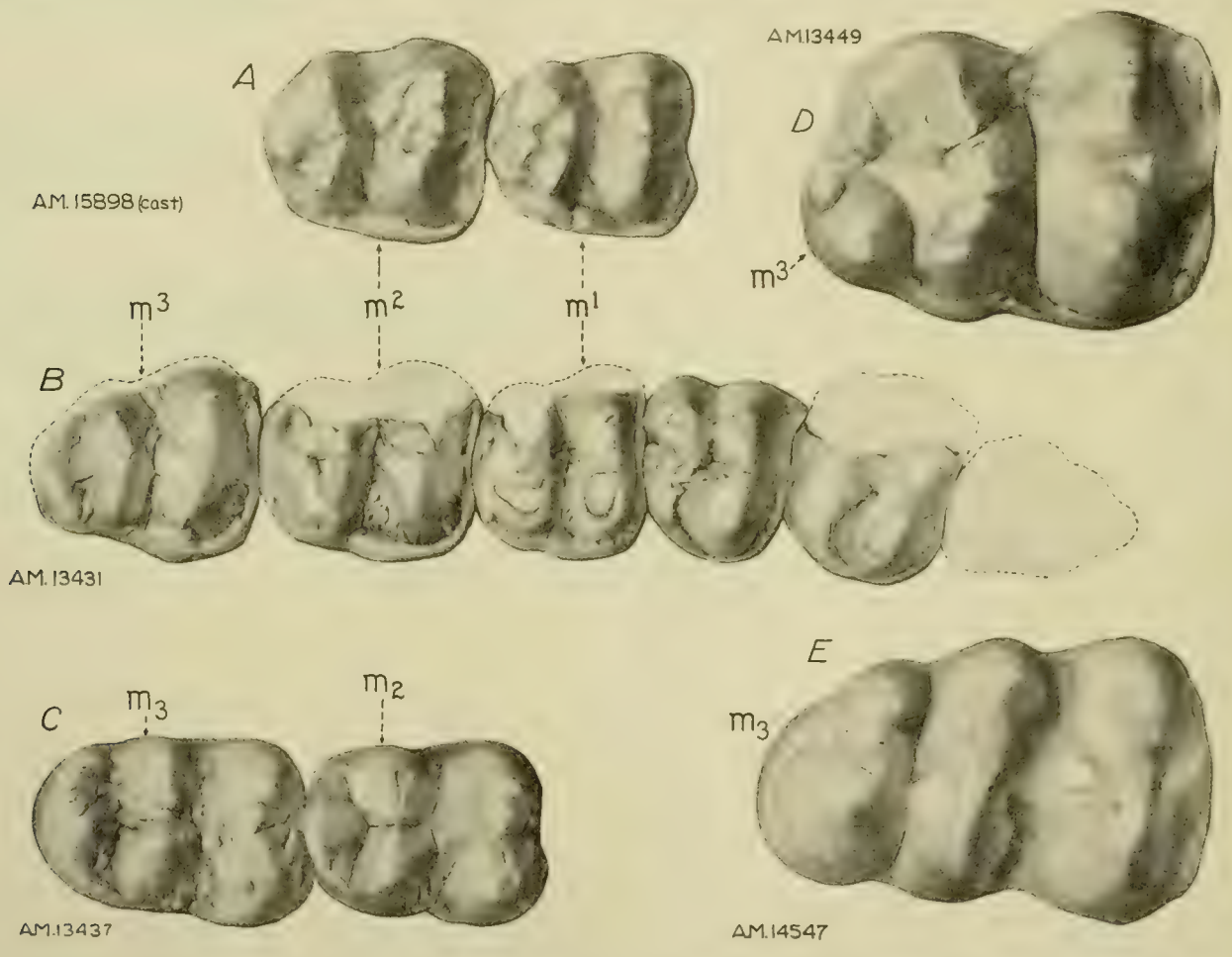


Fig. 49. *Mœritherium* (A, B, C) and *Palæomastodon* (D, E) grinders figured and compared in close detail, demonstrating that the *hexabunodont* grinders of *Palæomastodon* contrast with the *tetrabunodont* grinders of *Mœritherium*. See same figure in Chapter VI (Fig. 94), see also key figure 93. Natural size.

A, *Mœritherium lyonsi* ref. (Amer. Mus. 15898 cast). First and second right superior molars, M^1-M^2.
B, *Mœritherium trigodon* ref. (Amer. Mus. 13431). Right superior grinding teeth, P^2-M^3.
C, *Mœritherium andrewsi* ref. (Amer. Mus. 13437). Second and third inferior grinders, M_2-M_3.
D, *Palæomastodon intermedius* paratype (Amer. Mus. 13449). Third right superior molar, r.M^3.
E, *Palæomastodon intermedius* type (Amer. Mus. 14547). Third left inferior molar, l.M_3 (reversed in drawing).

TRILOPHODON (MŒRITHERIUM?) PANDIONIS (?)

Fig. 50. Incomplete fourth superior permanent premolar, P^4, possibly referable to *Trilophodon pandionis*. Originally referred by Pilgrim to *Mœritherium*. After Pilgrim, 1912, Pl. III, figs. 3, 3*a*: "*Mœritherium* (?) sp. Pilg. Upper molar, 3, surface view, 3*a*, side view. From the base of the Gaj near Khajuri, Bugti Hills. (Ind. Mus., No. A 452.) Page 15."

Provisionally, therefore, it may be regarded as an indeterminate species of the Egyptian genus. The measurements of the tooth are approximately as follows:—

Length	.42 mm.
Breadth	.31 "

Locality.—The specimen was found at Khajuri, near the very base of the series, and hence, is probably lowermost aquitanian."

Osborn, 1926: The supposed *Mœritherium* superior molar of Baluchistan proves to be a fourth superior premolar, P^4, probably referable to *Trilophodon pandionis*, a characteristic species of Sind, India. The original comparison by Pilgrim of this tooth with *Mœritherium lyonsi*, as quoted above, was qualified by his remark: "It is by no means unlikely that further material of the Bugti species will show that it belongs to a different genus from *Mœritherium*." Similar tetrabunodont superior premolar teeth occur as P^4-P_4 both in *Trilophodon* and in *Serridentinus;* such a tooth was selected by Cope as the type of his '*Mastodon*' *proavus* (=*Serridentinus proavus* of the present Memoir), as illustrated in figures 362 and 363.

Unfortunately Pilgrim's original reference of this premolar tooth to *Mœritherium*(?) has been widely quoted as demonstrating the presence of the genus *Mœritherium* in India.

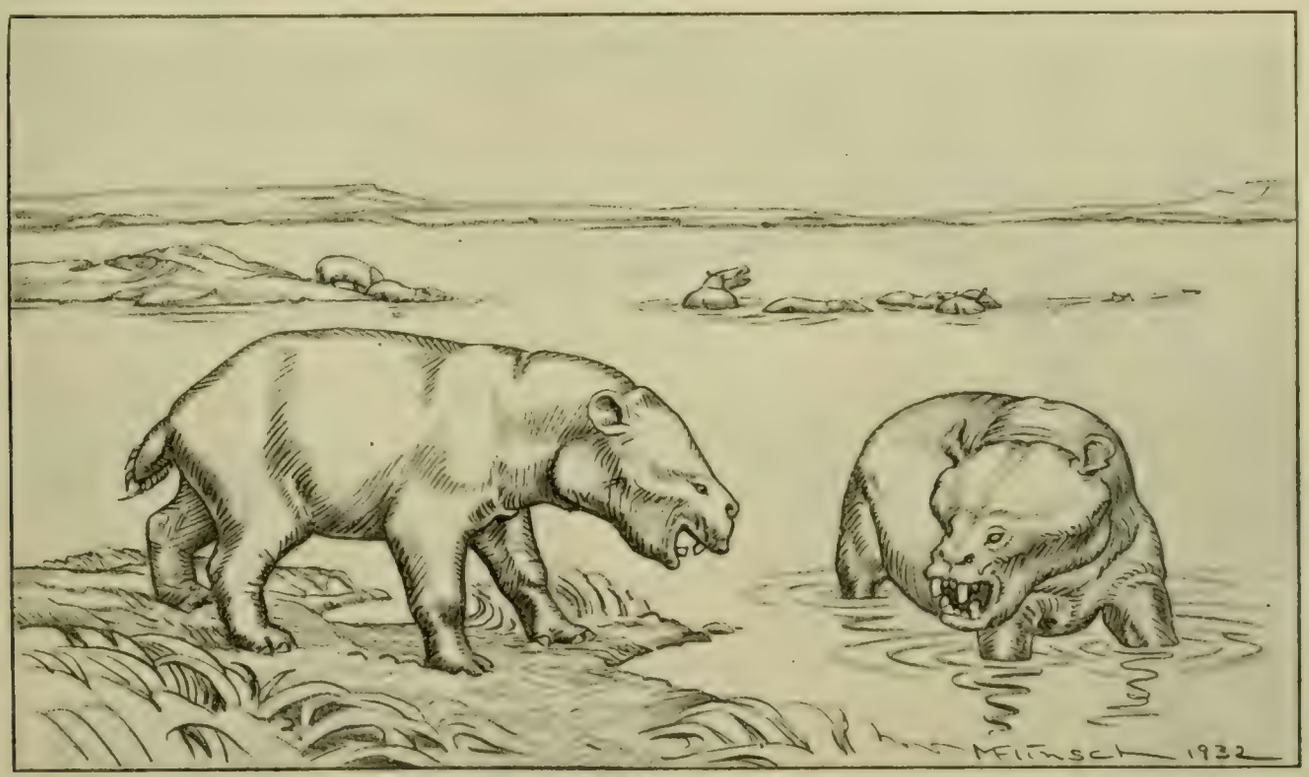


Fig. 51. Restoration (September, 1932) of *Mœritherium andrewsi*, after materials described and figured by Andrews (1906), Schlosser (1911), and Matsumoto (1922–1923), and reproduced in figures 41 and 42. One-sixteenth natural size.

This restoration embodies the Andrews-Matsumoto-Osborn conception of *Mœritherium* as of a swamp- and river-loving stock. As detailed above, the conclusion is, that it was a confirmed and continual river-living animal, feeding mainly under water and on the banks, as indicated by its feeble pelvis, more specialized for aquatic life than *Hippopotamus*, but less specialized than the Sirenians. The resemblances to the Sirenians are largely parallelisms. *Mœritherium* is one of the primary stocks of the Proboscidea. The marked resemblances to the river-living *Hippopotamus* are also parallelisms, namely, the small, elevated orbits, with small eyes and probably small ears, the elevation of the eye and ear openings to the upper level of the face, the prominent anterior tusks, the relatively short, stout limbs, probably encased in fat. The habitat was on a river-bed meandering over a low-grade flood-plain, as indicated in the restoration.

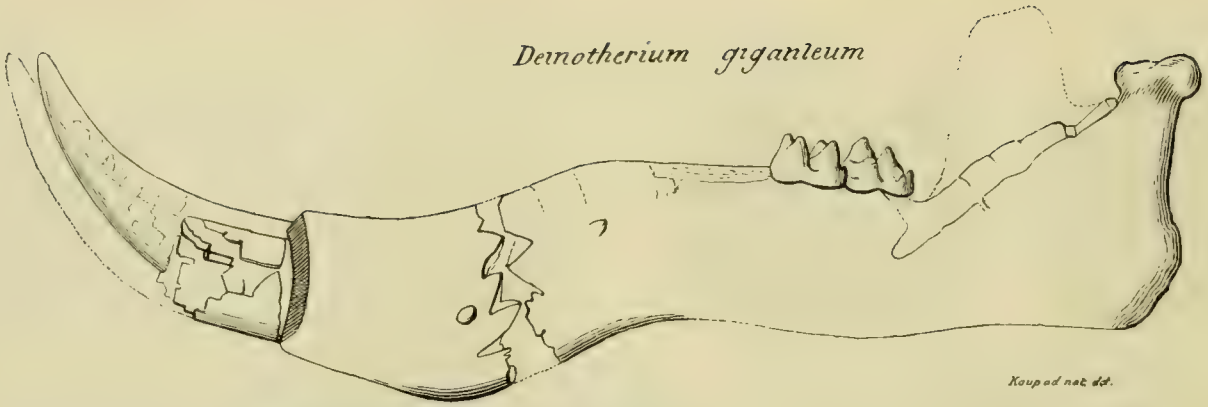


Fig. 52. Type of *Deinotherium giganteum* as originally figured by Kaup, with the incisive tusks erroneously upturned, 1829, XXII, Heft IV, Taf. 1, one-ninth natural size.

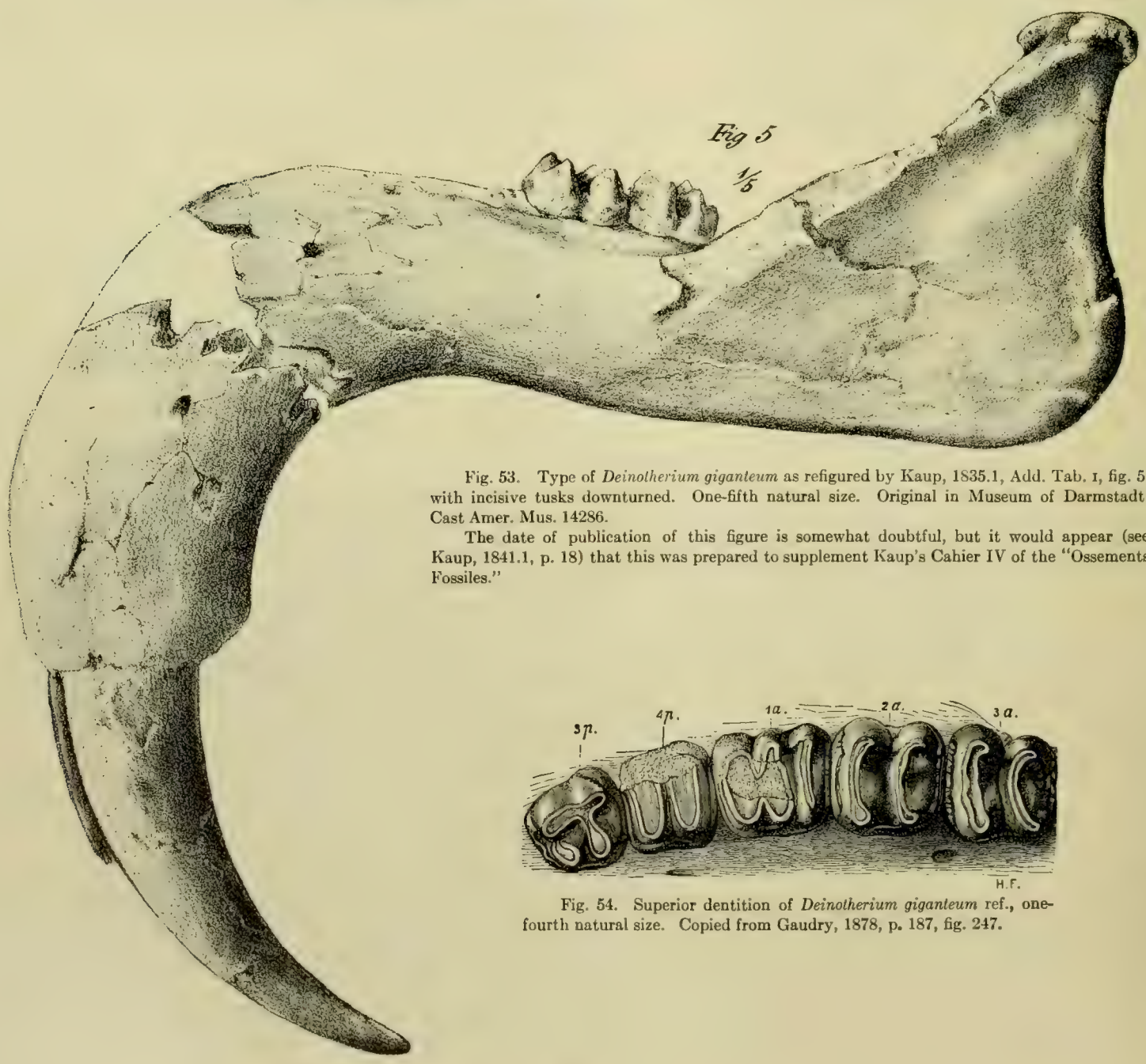


Fig. 53. Type of *Deinotherium giganteum* as refigured by Kaup, 1835.1, Add. Tab. 1, fig. 5, with incisive tusks downturned. One-fifth natural size. Original in Museum of Darmstadt. Cast Amer. Mus. 14286.

The date of publication of this figure is somewhat doubtful, but it would appear (see Kaup, 1841.1, p. 18) that this was prepared to supplement Kaup's Cahier IV of the "Ossements Fossiles."

Fig. 54. Superior dentition of *Deinotherium giganteum* ref., one-fourth natural size. Copied from Gaudry, 1878, p. 187, fig. 247.

Chapter IV

THE DEINOTHERES (DEINOTHERIOIDEA) OF WESTERN EURASIA AND OF AFRICA

I. Early separation of the deinotheres from the other proboscideans. Marked distinction by dental, cranial, and skeletal characters. Family, subfamily, and generic distinctions. Origin, habitat, migrations, phylogenetic succession, and extinction of the deinotheres.

II. Geologic distribution of deinotherium, trilophodon, anancus, rhynchotherium, zygolophodon, turicius, miomastodon, serridentinus, and tetralophodon. Causes of extinction.

1. Chief distinctions of the Deinotheres from other proboscideans.
2. History of discovery of the Deinotheres between 1715 and 1934.
   Historical summary by Weinsheimer, 1715–1882.
   Historical summary by Osborn, 1883–1934.
3. Résumé of the chief generic and specific characters.
4. Conclusions as to origin, phylogeny, and adaptive radiation.
5. Geologic distribution of *Deinotherium*, *Trilophodon*, *Anancus*, *Rhynchotherium*, *Zygolophodon*, *Turicius*, *Miomastodon*, *Serridentinus*, and *Tetralophodon*. Causes of extinction.

Appendix: *Deinotherium hungaricum* Ehik and *Deinotherium hopwoodi* sp. nov.

1. CHIEF DISTINCTIONS OF THE DEINOTHERES FROM OTHER PROBOSCIDEANS

It is not possible for the author to treat the Deinotheres in the same critical or exhaustive manner as the species of proboscideans belonging to other families are treated in the present Memoir; nor is it possible to give the type descriptions or reproductions of the type figures as in other chapters. Such exhaustive revision and monographic treatment can only be made after a tour of the museums of Europe and of India where the actual type specimens are to be found and the precise records of the type localities are given.

In the succeeding historical summaries by Weinsheimer and by Osborn there is recited the wide range of opinion as to the structure, habits, and ordinal relationships of these remarkable mammals between the date of the first description in 1715 and the present time; the author's personal opinions on these points are summarized at the end (pp. 112–115).

Following the ruling of the International Commission on Zoological Nomenclature, the generic name must be spelled *Deinotherium* throughout, in accordance with Kaup's original orthography of 1829 derived from the Greek δεινός and θηρίον. The same principle applies to the family name Curtognati, proposed by Kaup in 1833, which may be given the modern family terminal and orthography CURTOGNATHIDÆ, although as in all matters of proboscidean nomenclature the early authors naturally did not follow modern nomenclatural canons. The history of the term 'Curtognati,' equivalent in German to 'Krummkiefer,' in reference to the sharp downward curvature of the lower jaw, is given as follows in the Bulletin of the Geological Society of France for 1834 (Boué, Bull. Soc. géol. de France, 1834, V, p. 444):

Curtognati.—M. Kaup a reçu de nouveaux ossemens d'Eppelsheim, et a reconnu que le *Dinotherium medium* était véritablement bien différent du *D. giganteum.* M. Kaup a pu faire aussi quelques corrections et additions à sa description du *Dinotherium.* Il pense que ses deux énormes défenses ne lui servaient pas seulement pour extraire des racines de la terre, mais encore, comme à la morse, pour l'aider à mouvoir son corps si lourd. D'après la forme des os intermaxillaires, cet animal devait avoir une trompe pour porter la nourriture à sa bouche. Il est à placer entre les Mastodontes et les Bradypus, et il formerait une famille particulière à laquelle M. Kaup donne le nom de *Curtognati.* Elle serait caractérisée par la mâchoire inférieure courbée vers le bas, et les deux défenses dirigées vers le bas et en arrière (*N. Jahrb. f. Mineral., Geognosie,* etc., 1833, cah. 5, p. 509 [516] avec 1 pl.).

The following is from Kaup's original description, 1833.4, p. 516:

Nach meiner Ansicht steht es am besten zwischen Mastodon und Bradypus als eigene Familie, die ich Curtognati (Krummkiefer) nenne, und durch den nach Unten gekrümmten Unterkiefer mit den zwei Stoss-Zähnen ebenfalls nach Unten und Hinten gerichtet, charakterisire. Die Gattungs-Diagnose würde seyn $\frac{0}{2}$ Stoss-Zähne. Der ausführlichere Charakter: Keine Stoss-Zähne im Oberkiefer, zwei nach Unten gekrümmte Stoss-Zähne im Unterkiefer, $\frac{5}{5}$ Backen-Zähne, wovon der dritte dreihügelig, die übrigen zweihügelig, und nur der erste des Unterkiefers mit einem schneidenden Rand auf der vorderen Hälfte versehen ist. In der Jugend ist vor dem ersten Backen-Zahn noch ein überzähliger, und der Milchzahn des zweiten des Oberkiefers ist in die Länge gestreckt und dreihügelig. Rüssel, Krallen zum Aufscharren, Gang auf den Hand-Rändern, wie beim Faulthier.

In 1868 Falconer erroneously assigned the name *Antoletherium* to specimens from Attock belonging to the genus *Deinotherium;* this error was corrected by Lydekker in 1885.

Antoletherium Falconer, 1868. –(Falconer, 1868, I, p. 416): "Among the fossils discovered by Lieut. Garnett, near Attock, is a portion of the lower jaw of a tapiroid animal containing what appear to be the last premolar and the first and second true molars. Of this specimen I have received an excellent drawing executed by Col. Baker, who regarded the species as allied to Tapir. (Plate xxxiv. figs. 1 and 2.) The teeth certainly differ generically from those of *Dinotherium* in the massive connecting bridge between the two ridges, speedily running them into one confluent disc. The bend of the first ridge is very tapiroid. The specimen appears to me to be of an undescribed genus for which the provisional name *Antoletherium* (ἀντολὴ the east, and θηρίον) would be appropriate."

(Lydekker, 1885, p. 105): "A. 20. Fragment of the right ramus of the mandible, containing $\frac{\text{pm. 4, m. 1}}{\text{m. 2}}$; from Kushálgarh. Figured in 'Falconer's Palæontological Memoirs,' vol. i., pl. xxxiv., figs. 1 and 2 (as *Antoletherium*), and in the 'Pal. Ind.' *op. cit.* [Lydekker, 1880] pl. xxix., figs. 2, 3. Presented by Lieuts. Garnett and Trotter." No. A. 20 is listed by Lydekker (1885, p. 105) under specimens of *Dinotherium pentapotamiæ* in the Indian Museum, Calcutta. See also Lydekker, 1880, p. 184, in which he states: "As I have already observed in the above-quoted passage in the 'Records' [Geol. Surv. India, 1877, Vol. X, p. 33], the figure of this specimen given by Dr. Murchison in the 'Palæontological Memoirs' [Footnote: 'Vol. I, Plate xxxiv, figs. 1–2.'] under the name of *Antoletherium* is entirely incorrect. It appears probable that Dr. Falconer never saw the original specimen, but made his new genus *Antoletherium* solely on the evidence of the imperfect drawing from which the figure was taken; a copy (or the original) of this drawing was sent by Dr. Falconer to Professor Owen, whose note on the subject will be found on page 416 of the first volume of the 'Palæontological Memoirs.'"

Original and subsequent nomenclatural references and modifications for this Memoir are as follows:

Original Name	Reference in Present Memoir
Deinotherium Kaup, 1829, p. 401	=*Deinotherium*
Dinotherium Kaup, 1832. All subsequent authors adopted the abbreviated spelling	=*Deinotherium*
Curtognati Kaup, 1833	=CURTOGNATHIDÆ
Dinotheridæ Bonaparte, 1845, in his "Catalogo metodico dei Mammiferi Europei," cited by Palmer, 1904, p. 738	=CURTOGNATHIDÆ
Dinotheriidæ Bonaparte, 1850, cited by Osborn, 1918.468, p. 134	=CURTOGNATHIDÆ
Dinotherina Bonaparte, 1841 (1837, *fide* Graells, 1897, p. 573); Dinotheriina Bonaparte, 1850, cited as a subfamily	=Deinotheriinæ
Antoletherium Falconer, 1868	=*Deinotherium*
Dinotheriini Winge, 1906, p. 172	=Deinotheriinæ
Dinotheriinæ Osborn, 1910.346, p. 558	=Deinotheriinæ
Dinotherioidea Osborn, 1921.515, p. 2, "typified by the Miocene and Pliocene Dinotheres of Eurasia"	=DEINOTHERIOIDEA

The following is Osborn's definition of the suborder or superfamily DEINOTHERIOIDEA (Osborn, 1921.515, p. 3):

II.—Dinotherioidea. All agree that these animals were chiefly fluviatile and amphibious in habit, in this respect resembling Mœritheres but differing in the entire loss of the superior incisor teeth. Early loss of upper tusks released the inferior. In the downturning of the inferior tusks the Dinotheres are paralleled by the Rhynchorostrinæ among the Masto-

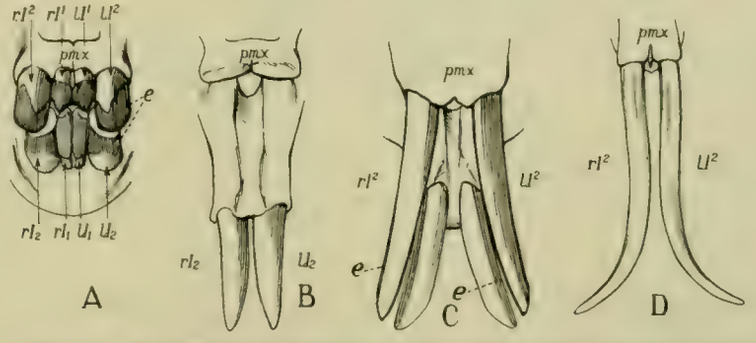


Fig. 55. Fundamental arrangement of the cutting teeth in the four superfamilies of the Proboscidea. For lateral aspect of the lower cutting teeth, compare fig. 1, p. 16. See also fig. 4, p. 23.

A.—*Mœritherium*. B.—*Deinotherium*. C.—*Rhynchotherium*. Composition of two species. D.—*Stegodon*. *S. ganesa* stage. Scale not uniform.

dontoidea. In skull form and in limb and foot structure the Dinotheres parallel the true proboscideans. They diverge very widely from proboscideans in the evolution of the upper and lower grinding teeth. The primitive Dinotheres present simple bilophodont grinders, similar to those of *Mœritherium*, and are persistently bilophodont. The upper grinders attain a stage which parallels the molar pattern of the tapir (*Tapiroides*[*Tapirus*]) among the perissodactyls, but show no tendency to the trilophodont, tetralophodont, or polylophodont structure characteristic of the mastodons and elephants.

Thus the technical range of classification and nomenclature for these animals stands as on the following page.

SUPERFAMILY: DEINOTHERIOIDEA Osborn, 1921
FAMILY: CURTOGNATHIDÆ Kaup, 1833
SUBFAMILY: DEINOTHERIINÆ Bonaparte, 1850, Winge, 1906, Osborn, 1910

GENUS: **DEINOTHERIUM** Kaup, 1829

So far as known the Deinotheres are certainly monophyletic. There is a single phylum of successive ascending mutations and species extending from the base of the Miocene, where they suddenly appear in Europe (*D. cuvieri*), to the Lower or Middle Pliocene of Rumania, where the pre-final stage is attained in *D. gigantissimum*. The final stage is *D. hopwoodi* of the Pleistocene of Africa.

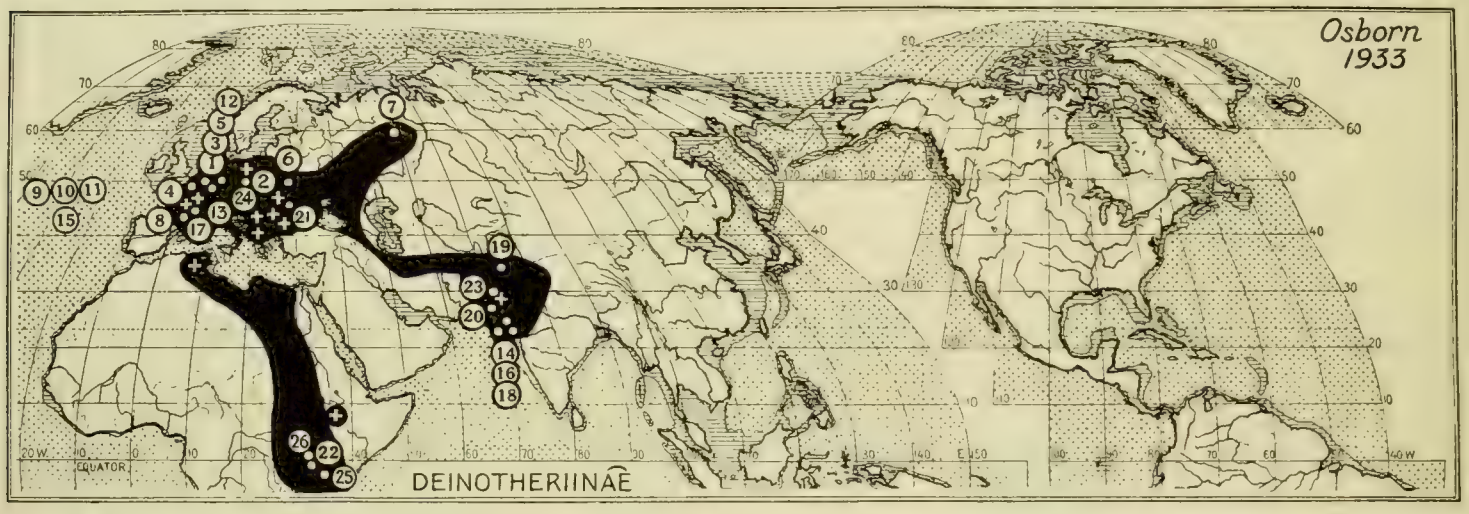


Fig. 56. Geographic distribution (according to the numbers in the list below) of the types of *Deinotherium*. The approximate localities where these twenty-six[1] types were found are represented by the white dots within the black areas; these dots each carry a number in a circle representing the chronologic sequence of type description. The white crosses represent referred specimens.

ORDER OF DISCOVERY AND DESCRIPTION OF TWENTY-SIX[1] SPECIES OF DEINOTHERIUM DESCRIBED OR NAMED, 1715–1935. COMPARE TABLE I, P. 111, AND TABLE II, PP. 114, 115

See Figure 56

		Original Name	Specific Reference in Present Memoir	Geologic Age
	1715 Réaumur publishes Antoine de Jussieu's drawing of a grinding tooth discovered near Lyons, France, in the previous century		= *Deinotherium* sp.(?)	
	1773 Rozier describes and figures a tooth discovered near Vienne, Dauphiny, France		= *Deinotherium* sp.(?)	
	1798–1822 Cuvier ascribes grinding teeth found in France to "Tapirs gigantesques"		= *Deinotherium* sp.(?)	
1.	1828–1829 Kaup describes a lower jaw from near Eppelsheim, Germany, now in the Museum of Darmstadt, assigning in 1829 the name	*Deinotherium giganteum*	= *Deinotherium giganteum*	Lower Pliocene
2.	1831 Gmünd, Bavaria	*Deinotherium Bavaricum* von Meyer	= *Deinotherium bavaricum*	Upper Miocene
3.	1832 Eppelsheim, Germany	*Dinotherium maximum* Kaup (MS.), *fide* von Meyer, 1832.2, p. 78	= *Deinotherium giganteum*	Lower Pliocene

[1]See No. 6a, p. 85, and footnote 1.

4.	1832	Comminge, Carlat-le-Comte, and Chevilly, France	*Dinotherium Cuvieri* Kaup	= *Deinotherium cuvieri*	Lower Miocene
	1833	Kaup proposes the family name CURTOGNATI for the Deinotheres		= CURTOGNATHIDÆ	
5.	1833	Eppelsheim, Germany	*Dinotherium medium* Kaup	= *Deinotherium medium*	Lower Pliocene
6.	1835	Podolia, Russia	*Dinotherium proavum* (*Dinotherii proavi* Eichwald)	= *Deinotherium proavum*	Upper Miocene(?)
6a.	1835–1837	Podolia, Russia	*Mastodon podolicum*[1] Eichwald	= *Deinotherium podolicum*	Pliocene(?)
7.	1835	Ural Mountains	*Dinotherium uralense* Eichwald	= *Deinotherium uralense*	Lower Pliocene
8.	1836	Simorre, France	*Dinotherium secundarium* Kaup (*teste* Lartet, 1836, p. 218)	= *Deinotherium secundarium* (?)	Middle Miocene
9.	1839	Locality (?)	*Dinotherium* [*gig.*] var. *majus* de Blainville (*fide* Weinsheimer, 1883, p. 210)	= *Deinotherium giganteum*	Lower Pliocene
10.	1839	Locality (?)	*Dinotherium* [*gig.*] var. *medium* de Blainville (*fide* Weinsheimer, 1883, p. 210)	= *Deinotherium giganteum*	Lower Pliocene
11.	1839	Locality (?)	*Dinotherium* [*gig.*] var. *minus* de Blainville (*fide* Weinsheimer, 1883, p. 210)	= *Deinotherium giganteum*	Lower Pliocene
12.	1841	Eppelsheim, Germany	*Dinotherium Königii* Kaup		Lower Pliocene
13.	1841	Mösskirch, Germany	*Dinotherium minutum* von Meyer (in Bronn)		Upper Miocene
	1843	Darling Downs, Australia	*Dinotherium Australe* Owen	= *Diprotodon australis* (not a proboscidean)	
14.	1845	Compubay [Cambay, cf. p. 90], India	*Dinotherium angustidens* Koch	= *Deinotherium* sp.(?)	Middle Pliocene
15.	1845	France	*Dinotherium intermedium* de Blainville	= *Deinotherium intermedium*	Upper Miocene(?)
16.	1845	Perim Island, India	*Dinotherium indicum* Falconer	= *Deinotherium indicum* (*fide* Lydekker)	Middle Pliocene
17.	1861	Grive Saint-Alban, Isère, France	*Dinotherium levius* Jourdan	= *Deinotherium levius*	Upper Miocene
18.	1868	Perim Island, India	*Dinotherium Perimense* Falconer, cited in Murchison (name only)	= *Deinotherium indicum*	Middle Pliocene
19.	1876	Attock, Indus Valley, India	*Dinotherium pentapotamiæ* Lydekker	= *Deinotherium indicum*	Upper Miocene
20.	1880	Sind, India, Salt Range	*Dinotherium sindiense* Lydekker	= *Deinotherium sindiense* (?)	Middle Miocene
21.	1892	Găiceana, Tecuciŭ, Rumania	*D.* [*Dinotherium*] *gigantissimum* Stefănescu	= *Deinotherium gigantissimum*	Middle Pliocene
	1908	Bugti beds, Bugti Hills, Baluchistan	*Dinotherium náricum* Pilgrim (name abandoned by author and subspecific term *gajense* substituted—see below)	= *Deinotherium indicum gajense*	
22.	1911	Karungu, British East Africa	*Dinotherium hobleyi* Andrews	= *Deinotherium hobleyi*	Lower Miocene
23.	1912	Bugti beds, Bugti Hills, Baluchistan	*Dinotherium indicum* Lyd. var. *gajense* Pilgrim	= *Deinotherium indicum gajense*	Lower Miocene
24.	1930	Kotyháza (Dep. Nógrád, Hungary)	*Prodinotherium hungaricum* Ehik	= *Deinotherium hungaricum*	Lower Miocene
25.	1935	Olduvai, Tanganyika Territory, British East Africa	*Deinotherium hopwoodi* sp. nov.	= *Deinotherium hopwoodi* sp. nov.	Middle Pleistocene
26.		Kavirondo Gulf, Africa	*Deinotherium*[2] sp.? Leakey	= *Deinotherium hopwoodi* (?)	Pleistocene

2. HISTORY OF DISCOVERY OF THE DEINOTHERES, 1715–1934

The history of discovery is most picturesque and even romantic because of the wonder and astonishment caused by the discovery of these pre-Diluvian mammals and the many and often grotesque theories as to their habits and external appearance.

For the early history of discovery up to the year 1883 we may depend chiefly on the extremely thorough and scholarly article published by Dr. O. Weinsheimer in the Palæontologische Abhandlungen, Band I, Heft 3, Berlin, 1883, entitled, "Über Dinotherium giganteum Kaup," pp. 208–216. This history we have translated with

[1]Type mandibular symphysis. First named *Mastodon podolicum* by Eichwald in 1835 (p. 736, Tab. LVI, LVII, see also p. 734); subsequently (Neues Jahrb., 1837, p. 44) referred by Eichwald to *Deinotherium*. Falconer (1846, p. 4) states in a footnote that the specimen appears to be a fragment of the symphysis of the lower jaw of *Deinotherium giganteum*.

[2]An undescribed specimen, of Pleistocene age, associated with the type remains of *Homo kanamensis* (see Leakey, 1934, pp. 204, 206, 207, also p. 105 of the present Memoir).

marginal inserts and a few comments of our own together with illustrations of some of the important specimens alluded to by Doctor Weinsheimer in his interesting narrative of the progress of discovery. For the bibliography of the Deinotheres, the reader is referred not only to Weinsheimer and to the authors mentioned by him in the following historical summary but to the Bibliography at the close of the present Volume I. The more recent history of discovery is compiled by Osborn (p. 95).

HISTORICAL SUMMARY BY WEINSHEIMER, 1715–1882

Translated by C. D. Matthew from the original of Weinsheimer, with notes, modifications, and additions by Osborn, 1925

Réaumur, 1715.—In 1715 Réaumur (1715)[1] published an illustration from a drawing by Antoine de Jussieu of a tooth of *Deinotherium* found near Lyons in the beginning of the previous century, without, however, ascribing it to any particular animal. From that time no further remains of this remarkable animal of the Miocene Tertiary were found until Rozier (1773) described and figured another –a molar tooth discovered in Dauphiny in the neighborhood of Vienne by Gaillard—without knowing of the tooth previously figured by Réaumur.

The third and most remarkable discovery of *Deinotherium* remains was of two lower jaw fragments, unearthed near Comminge, France, and described and figured by de Joubert (1785). In the same year Ildephons Kennedy (1785) published his "Abhandlung von einigen in Baiern gefundenen Beinen," in which he describes five teeth and an astragalus as the best preserved parts of a complete skeleton of *Deinotherium* found April 6, 1762, near Reichenberg in Lower Bavaria. Kennedy says that these remains show striking resemblance to remains [of mastodonts] from the Ohio River in North America, from Peru in South America, from Asia, and from the small town of Fürth in Lower Bavaria (1785, t.2 [IV], f.6), and remarks at the close of his article that these remains belonged to an animal that had long been extinct, and that could not be distinguished from the Siberian mammoth, the "Ochsenvater der Louisianer."

Cuvier, 1798–1822.—These teeth, described by de Joubert and Kennedy, were more carefully studied by G. Cuvier (1798) who, on account of their similarity to the teeth of the tapir, ascribed them to some gigantic extinct individual of that genus, which was contemporary with *Mastodon* and *Elephas*. Some of the teeth which Kennedy described were better figured by Sömmering (1818) who ascribed them to Cuvier's giant tapir. Other teeth and jaws of *Deinotherium*, or fragments of such, were found later at various sites in France, such as St. Lary, Arbeichan, Grenoble, Carlat-le-Comte, Chevilly, and others, and—together with the specimen already described by Cuvier (1822)—ascribed to a new genus; these Cuvier named "Tapirs gigantesques," for he already suspected, in spite of their similarity of form, that on account of their great variation in size they did not belong to one single species, and therefore he used the plural.

Kaup, 1828–1829.—Somewhat later Kaup (1829) made a report to the Naturforscherversammlung of Berlin, through Berthold, describing the left half of a large lower jaw, found in 1828 near Eppelsheim in Hesse-Darmstadt and sent to the Museum of Darmstadt where it remains to the present day. Much as the molar teeth in this jaw resembled those of the tapir, the teeth in the anterior part of the jaw were so widely different from the corresponding ones in the tapir that Kaup felt justified in distinguishing a new genus and species, *Deinotherium giganteum*, which he believed to be related to *Hippopotamus*. The tusks of the lower jaw he erroneously placed [Fig 52] pointing upward.

Since that time—particularly during the 30's—a great many remains of *Deinotherium* have been found at various sites in Europe, that is, in France and Germany, as well as in Asia, so that the material and the literature

[1] Dates in parentheses after authors' names refer to the bibliographic list given on pp. 214–216 of Weinsheimer's article.

respecting this genus are now very extensive. Moreover, the various authors who have occupied themselves with the specimens have reached widely divergent conclusions in regard to the dentition, the various species, and the classification of *Deinotherium*.

Theories as to Habits and Habitat.—Thus, according to Kaup (1832), *Deinotherium* apparently had four to six tusks in the upper jaw and two in the lower jaw, which were used to stir up the earth when seeking the roots of which its food consisted. There were apparently six molars in the upper jaw, and to all appearances yet a seventh, anterior to these, which, however, as in *Hippopotamus*, was lost early. In the lower jaw, on the contrary, there were only five molars. He distinguishes two species—one large, *Deinotherium giganteum* Kaup, and one smaller, *Dinotherium Cuvieri* Kaup.

According to H. von Meyer (1833 [1832.1]) *Deinotherium* is most nearly related to *Rhinoceros incisivus;* he recognizes the same species as Kaup, but—on account of its frequent occurrence in Bavaria—he calls the Bavarian animal *Deinotherium bavaricum*, which is one quarter smaller than *Deinotherium giganteum*. He dissents from Cuvier's view that *Deinotherium* was contemporary with *Mastodon* and *Elephas* because their remains have never been found associated, claiming that it was contemporary with *'Mastodon' angustidens* and *Rhinoceros incisivus*, and became extinct earlier than the mastodon of Cuvier, and that it belongs to the latest Tertiary deposits. In the plates given by Kaup (1832) and H. von Meyer (1833 [1832]) the tusks of the lower jaw are pictured pointing upward.

Kaup, 1833.—In 1833 the Museum of Darmstadt (Kaup, 1833, p. 419) acquired an almost perfect left half of a lower jaw from Eppelsheim, from which it could be seen that the anterior part of the jaw was inclined downward, whereupon Kaup (1833, [1833.4, Taf. vii], p. 509) corrected his earlier mistake (1829—see our figure 52). He now states that *Deinotherium* lived only on land, on which—like the sloth *Bradypus*—it dragged itself along. Its principal food consisted of roots and tubers which it dug out of the earth with the two tusks of its lower jaw, and stuffed into its mouth with its trunk (Kaup, 1833 [1833.2], p. 172); but the tusks also served, like those of the walrus, to help its progress on land. It forms a separate family, intermediate between *Mastodon* and *Bradypus*, which he named Curtognati (i.e., crooked jaw: Kaup, 1833 [1833.4], p. 509 [516]).

Pallas (1777)—Eichwald (1835).—Eichwald (1835) describes two molars from Podolia found associated with teeth of *Mastodon podolicum*,[1] and assigns them to a new species which he names *Dinotherium proavum*. In it he also includes a molar from the Ural described by Pallas (1777), subsequently (1835) named *Dinotherium uralense*.

Lartet (1835 [1836]).—Lartet (1835) ascribed a few teeth found in the sands of the freshwater deposit of Sansan, Gers, to the species *D. secundarium* Kaup.

Buckland, 1835.—From the existence and downturned position of the tusks Buckland (1835) draws the following conclusions in regard to the life and habits of *Deinotherium*. For a land animal the monstrous lower jaw and the consequent length of body would be very cumbrous and wearisome. With an aquatic animal these would not be disadvantages. He considers, therefore, disagreeing with Kaup (1833 [1833.2], p. 172), that *Deinotherium* frequented freshwater lakes and rivers, and was most nearly related to the tapirs. The tusks were used for uprooting and plucking roots and large aquatic plants. From their construction it is seen that for this purpose they united the mechanical strength of the pickaxe with that of a very heavy harrow. The weight of the head, pressing on the downwardly pointing teeth, would increase the effectiveness of such a use, just as a heavy weight is fastened to a harrow to increase its effect. Possibly *Deinotherium* also used its tusks to lay hold of the bank and so to

[1]See footnote 1 on page 85.

anchor itself. Thus the nostrils would come above the level of the water, so that the creature might sleep without danger and could breathe, while its body, floating in the water, remained concealed with the muscles relaxed and resting; for the weight of head and body would also serve to keep the tusks fast hooked in the same place, like the weight of a sleeping bird whose claws hold it fast to the branches on which it sits. It is also most probable that *Deinotherium*, like the walrus, used its tusks to drag itself on the land, or in case of danger or of attack as a means of defense. From the construction of the shoulder-blade it is clear that the fore feet were used in conjunction with the tusks for uprooting and dragging out roots and large aquatic plants. Hind limbs it did not have.

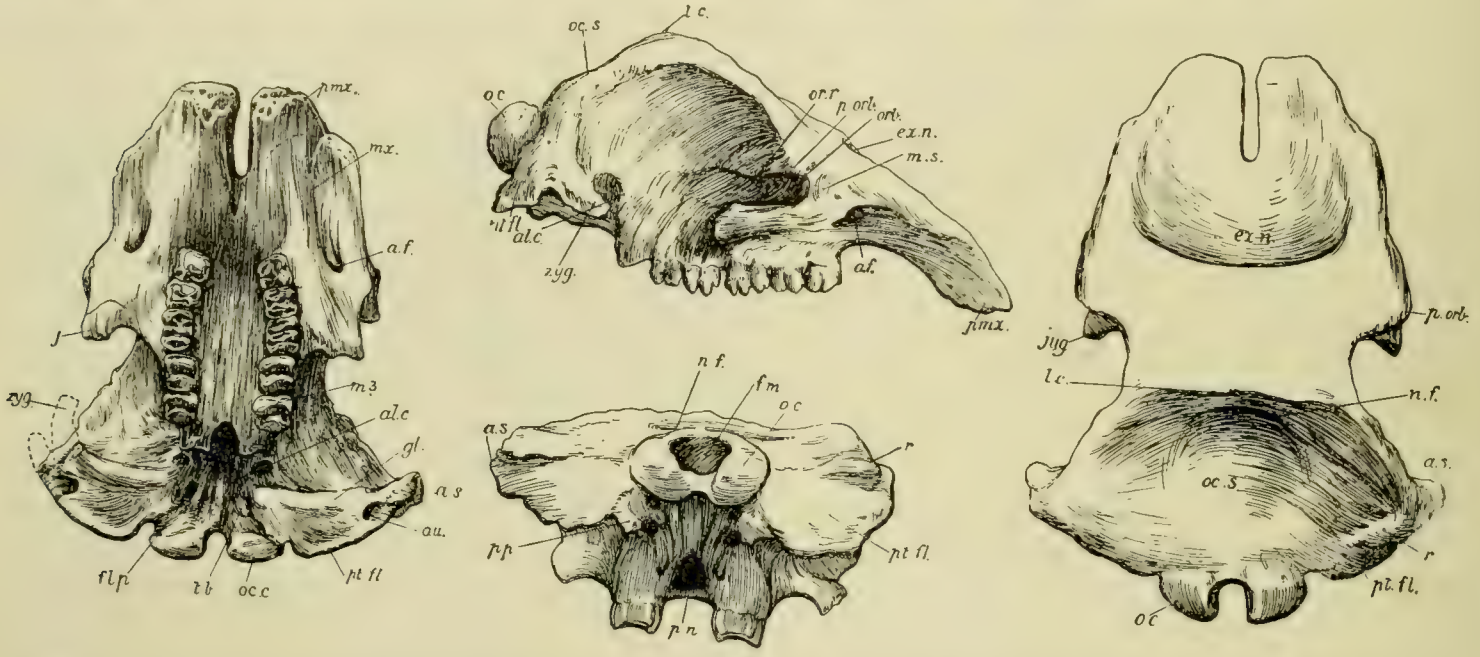


Fig. 57. Four views of the reconstructed original Eppelsheim skull of *Deinotherium giganteum* in the British Museum (Natural History). After Andrews, 1921, pp. 525–534, figs. 1–4.

This is the first skull found at Eppelsheim and referred to by Weinsheimer (1883, p. 210) as having been exhibited in Paris, March 15 and 16, 1837, to the members of the Academy of Sciences and other savants for their consideration, resulting in widely divergent views, and afterward sold to the British Museum in London.

According to Andrews (1921, pp. 525, 526), this skull was discovered in 1835 by von Klipstein in the well-known ossiferous sands of Eppelsheim (Hesse-Darmstadt); the specimen was described by von Klipstein and Kaup in 1836 under the title "Beschreibung und Abbildungen von dem in Rheinhessen aufgefundenen colossalen Schädel des Dinotherii gigantei"; while in Paris the skull was examined by de Blainville, who has given one of the best descriptions as yet published; it was then intended to send the specimen to London, but whether this was done at that time is uncertain; some years later, in 1849, it was certainly in London, and was offered to the British Museum for purchase; it was then examined and reported on by Buckland and Owen; the purchase, however, was not completed, and the skull seems to have been sent back to Darmstadt. About 1866, von Klipstein sold his collection to Dr. Oldham, Director of the Geological Survey of India, and from him the British Museum acquired the specimen, which is in an excellent state of preservation, despite the widespread idea that it was injured on its journey to London.

Kaup and von Klipstein, 1836.—Shortly after, one of the most interesting palæontological discoveries was made in the Lower Pliocene of Eppelsheim, Germany, namely, a complete skull of *Deinotherium* which was described by Kaup (von Klipstein and Kaup, 1836). Kaup holds to his original view, and thinks that the walrus-like structure of the posterior half of the skull—on account of which Buckland considered *Deinotherium* an aquatic animal—offers no difficulties, and that such a flattened occipital region would permit the insertion of more powerful muscles than an abruptly ending occiput. Beside, these muscles would have to be excessively powerful if *Deinotherium* used its tusks for tearing and rooting up the earth. This Eppelsheim skull—later sold to the British Museum in London, uninjured in transport—was exhibited by von Klipstein and Kaup in Paris, March 15 and 16, 1837, to the members of the Academy of Sciences and other savants for their consideration, and again there resulted widely divergent views. [See Fig. 57 of the present Memoir.]

De Blainville, 1837.—Thus de Blainville (1837.1) gives a minute description of the Eppelsheim skull, and classes *Deinotherium* as a genus belonging to the family of aquatic pachyderms [i. e., Sirenia] together with *Halicore* and *Manatus*, while *Elephas*, *Mastodon*, and *Tetracaulodon* belong to the terrestrial pachyderms [i. e., Proboscidea]. In regard to the habits of *Deinotherium* he practically agrees with Buckland. Later (1839) de Blainville recognizes two species, *Dinotherium Cuvieri* Kaup (1832) and *Deinotherium giganteum* Kaup (1829), and of the latter he distinguishes three separate varieties—*Dinotherium majus* de Blain., *Dinotherium medium* de Blain., and *Dinotherium minus* de Blain.—based on the size of the teeth.

Duméril (1837, p. 427) and Isidore Geoffroy Saint-Hilaire (1837, p. 429) agree with de Blainville, while Strauss (1837, p. 529) considers *Deinotherium* exclusively aquatic and not able, like *Hippopotamus* and *Manatus*, to come on land. From the large narial openings he concludes that it had a trunk—the existence of which de Blainville

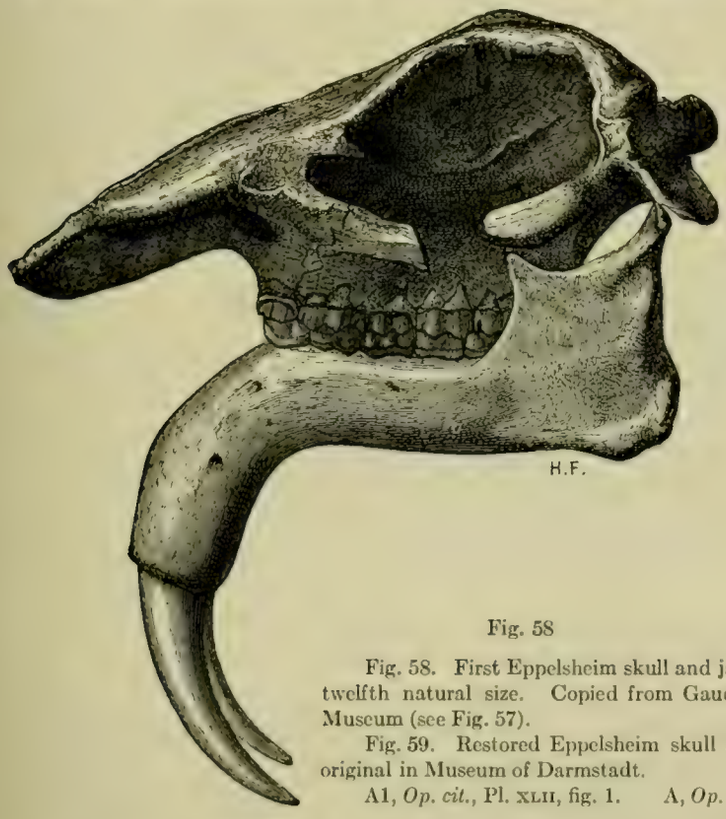


Fig. 58

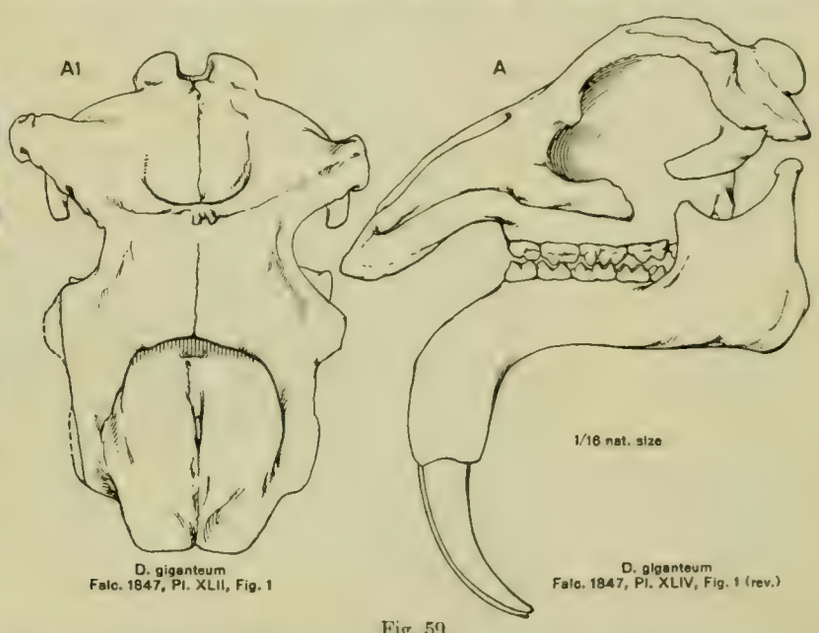


Fig. 59

Fig. 58. First Eppelsheim skull and jaws of *Deinotherium giganteum*, after the cast and restoration of Kaup, about one-twelfth natural size. Copied from Gaudry, 1878, p. 188, fig. 248. Type jaw in Darmstadt Museum; skull in British Museum (see Fig. 57).

Fig. 59. Restored Eppelsheim skull and jaws of *Deinotherium giganteum* Kaup. After Falconer, 1846 [1847], from original in Museum of Darmstadt.

A1, *Op. cit.*, Pl. XLII, fig. 1. A, *Op. cit.*, Pl. XLIV, fig. 1 (rev.).

doubted—used like that of the elephant for seizing food. The tusks were not used for uprooting plants, because they showed no signs of wearing down, but were used like those of the elephant for self-defense only. It formed a separate family, transitional between pachyderms and cetaceans. Jacquemin (1837) placed it between *Rhinoceros* and *Elasmotherium*, and Owen (1840) between the tapir and the pachyderms with trunks. Owen [1840–1868] gives the dental formula of *Deinotherium* as follows:

1. Deciduous teeth; $Di\frac{1-1}{1-1}$; $Dc\frac{0-0}{0-0}$; $Dp\frac{3-3}{3-3}=16$.
2. Permanent teeth; $I\frac{0-0}{1-1}$; $C\frac{0-0}{0-0}$; $P\frac{2-2}{2-2}$; $M\frac{3-3}{3-3}=22$.

He claims that of the three milk molars in the young animal, the anterior has no corresponding permanent tooth, that the tusks of the male are twice as large as those of the female, and that in both cases they were used for uprooting aquatic plants, since, like *Hippopotamus*, it was an aquatic pachyderm.

Kaup, 1841.—After the discovery of the first great [Eppelsheim] skull [now in the British Museum (Natural History)], the Museum of Darmstadt received a great number of additional *Deinotherium* remains from Eppelsheim

and Westhofen, which Kaup studied and described in the "Akten der Urwelt" in 1841. By that time he already had extensive material at his disposal, including the complete [Eppelsheim] skull, three skull fragments, 13 lower jaws, and 115 molar teeth. He now changes his former views, and considers that the adult *Deinotherium* had only five molars in both upper and lower jaw, while in the young six were present, anterior to the first being a "superfluous" one which, however, soon fell out.

All the teeth of *Deinotherium* previously known belonged to only one species [i. e., *D. giganteum* Kaup] with a wide range of variation in size. *Dinotherium proavum* Eichwald [1835], *Dinotherium medium* Kaup [1833.3] (see below), *Dinotherium Cuvieri* Kaup [1832] sive *bavaricum* H. von Meyer [1831] are therefore not admitted by Kaup as species. These teeth do not justify the recognition even of large or small varieties. Nevertheless Kaup introduces (1841, p. 49) in addition to his *Deinotherium giganteum* a new species which he calls *Dinotherium Königii* Kaup.

'*Dinotherium giganteum* varies greatly in size, so that individuals of this species may have attained a length of 18 Parisian feet, while others again may have been barely 11 feet long.' On the other hand, the smaller species, *Dinotherium Königii*, is supposed not to have exceeded the Indian *Rhinoceros* in length. In regard to the life and habits of *Deinotherium* Kaup reiterates his former opinions.

Fig. 60. De Blainville's original type figure of *Dinotherium intermedium*, 1839–1864 [1845], Pl. III. Possibly from the Upper Miocene of Simorre (cf. p. 111). Right mandibular ramus. One-third natural size.

Owen's Error, 1843.—Up to 1843 remains of *Deinotherium* had been found only in Europe, but now it was claimed that remains of the creature had also been found in Australia. Certain of these were sent to London and studied by Owen (1843) who ascribed them to a separate species which he named *Dinotherium australe* Owen. Later, however, these remains were recognized as belonging to [the giant marsupial] *Diprotodon*.

Koch, 1843.—In 1843 Koch (1845, p. 41) saw in the British Museum in London a part of a lower jaw, discovered in Compubay,[1] western India, and labeled "*Mastodon angustidens*." By a detailed examination he found that it did not belong to the genus *Mastodon* but to *Deinotherium*, and, if not to a very old specimen, at least to one fully adult, which—on account of the comparatively small molars—he named *Dinotherium angustidens* Koch. He completely agrees with Buckland (1835) in regard to its life and habits, and classes it with the Proboscidea as intermediate between *Tetracaulodon* Godman and *Missourium* Koch. Geinitz (1846) agrees with him.

Falconer, 1845.—Shortly after this remains of *Deinotherium* were also found in western India. Falconer (1846[1845]) describes the posterior half of a lower left molar of *Deinotherium* from a chalky ferruginous conglomerate

[1"Im Jahre 1843 sah ich im britischen Museum zu London eine in Compubay in Ostindien aufgefundene, mit der Ueberschrift: '*Mastodon angustidens*' versehene untere Kinnlade." (Koch, 1845, p. 41.) For "Compubay," a locality not on any existing map, probably read Cambay, western India.]

from Perim, a small island at the mouth of the Narbada [Nerbudda River] in the Gulf of Cambay on the west coast of India, which differs from the corresponding parts of an Eppelsheim tooth in having the transverse crest and the enamel thicker. He therefore ascribes it to a new species which he names *Dinotherium indicum* Falconer. He considers *Deinotherium* very nearly related to *Mastodon Ohioticus* (Falconer, 1868, I, p. 85) and belonging likewise to the Proboscidea.

Gervais, 1848.—Gervais (1848) classes *Deinotherium* with *Mastodon* in the order Proboscidea, and recognizes three species—*Deinotherium giganteum, Dinotherium intermedium* de Blainville (see fig. 60), and *Dinotherium Cuvieri*—while Wagner (1850), Girard (1851 [1852]), and Pictet (1853) continue to place it in the order Sirenia. Burmeister (1851) holds it for an herbivorous sea monster, 15–20 feet long, with short, thick neck, powerful, slender rump, and broad, effective flippers for creeping like the walrus, which like all the Sirenia frequented the mouths of large rivers, and used its tusks for assisting its movements on shore and for uprooting aquatic plants.

Discoveries in Western Europe, 1850–1858.—Again in the 50's a great number of remains of *Deinotherium* were found in a variety of places, and announced chiefly in brief reports. Opinions in regard to species, dentition, and classification continued divergent. Jäger (1850) reports the occurrence of *Dinotherium Cuvieri* Kaup sive *bavaricum* H. von Meyer at Mösskirch [Upper Miocene], and of *Deinotherium giganteum* Kaup near Salmendingen in the pisolitic iron ores of the Swabian Alb. Quenstedt (1851 [1850]) reports the occurrence of the latter in the pisolitic iron ores of Melchingen south from Tübingen, and later (1853) in those of Frohnstetten, and says that *Deinotherium* had not five, but six, molars in both jaws. Von Hingenau (1852) found molars near Nikolsburg and Keltschau; Glocker (1852) a tusk and several molars in the blue marl near Abtsdorf; Fötterle (1853) the right half of a lower jaw with tusk near Fünfkirchen and a molar near Keltschau; and Merian (1854) a molar in the Delsberg valley in the Bernese Jura. Pomel (1854 [1853]) classes *Deinotherium* with *Elephas* and *Mastodon* among the Proboscidea; Bronn (Lethaea, III, p. 803) as intermediate between Sirenia and Pachydermata; and Agassiz (Bronn, Lethaea, III, p. 805) among the herbivorous Cetacea.

In 1853, in consequence of the collapse of an embankment on the Prague-Brünn railway, a skeleton of *Deinotherium giganteum* was exposed in the blue marl near Abtsdorf, the bones of which lay together, covering a space about 24 feet long and 18 feet wide. Many of them fell to dust after being for a time exposed to the air; others, before word of the discovery was noised abroad, were shattered or cleared away. All that was preserved was the complete jaws and dentition, the first and second cervical vertebræ, a few dorsal and caudal vertebræ, a large part of the tarsus and metacarpals, and a few large fragments of the limb bones. These skeletal parts of a juvenile specimen, which are now in the Bohemian Museum of Prague, prove incontestably that *Deinotherium* should be classed not with the Cetacea, but with the Pachydermata as nearly allied to *Mastodon* (Reuss, 1855). Nevertheless Giebel (1855) again classes it among the Sirenia as nearly allied to *Halitherium*.

Deinotherium remains were found in France at this time by Lockhart (1853) in the Department of Loiret: by Bayle (1855) near La Chaux-de-Fonds in the Miocene Molasse which is identical with the deposit of Simorre and Sansan [Miocene] and the Faluns of Touraine; and by Rouault (1858) near Rennes, his discovery consisting of a large molar of *Dinotherium Cuvieri*. Hauser (1856) discovered remains of a *Deinotherium* skull in the Leitha chalk near Breitenbrunn on the Neusiedler See, Hungary. Gaudry and Lartet (1858) found a tibia 95 cm. long, and Wagner (1857) a skull fragment with five permanent teeth and a forearm of a young individual at Pikermi [Lower Pliocene]. Wagner believes that all *Deinotherium* remains known up to this time belong to one and the same species. Aichhorn (1857) found teeth of *Deinotherium giganteum* near Wies in Steiermark [Miocene]. Fötterle (1857) found a fragment of the right side of the chin with a molar and several bones of the torso embedded in fine

sand intermixed with rubble (Schotter) lying above the upper brackish blue marl. At other sites in Austria Poppelack (1858), Hörnes (1858), and von Hingenau (1858) found various more or less important remains of *Deinotherium*.

Lartet, 1858 [1859]. –Lartet (1858) holds the opinion that the first dentition in the upper jaw of the young *Deinotherium* consists of three milk teeth on either side, followed by the first molar of the second dentition, and then by the second molar. The first milk tooth falls out but is not replaced; the second and the last are replaced by premolars which are simpler than the corresponding milk teeth. Accordingly he gives the following dental formula:

1. First dentition: $Di\frac{0-0}{1-1}$; Dp $2\text{-}4\frac{3-3}{3-3}=14$.
2. Second dentition: $I\frac{0-0}{1-1}$; P $3\text{-}4\frac{2-2}{2-2}$; $M\frac{3-3}{3-3}=22$.

Lartet recognizes four species:

1. *Dinotherium giganteum* Kaup, syn. *Dinotherium proavum?* Eichwald.
2. *Dinotherium* sp.? Lartet.
3. *Dinotherium bavaricum?* H. v. Meyer, syn. *Dinotherium intermedium?* de Blainville.
4. *Dinotherium Cuvieri* Kaup.

Gaudry, 1860–1878.—Gaudry (1860) in his excavations at Pikermi, Greece [Lower Pliocene], collected a great number of skeletal fragments of *Deinotherium giganteum* which he considers as an ambulatory terrestrial animal related to *Mastodon* and *Elephas*, which was also his opinion in 1861 and 1862 when (p. 162) he gives a detailed description of the Greek remains and feels obliged to consider the various species of *Deinotherium* merely as varieties of one species (l. c. p. 171). Miller (1861) feels obliged to doubt whether *Deinotherium* was exclusively an aquatic animal, and Hensel (1862 [1863]), on account of its skeletal structure, classes it among the pachyderms with trunks. Suess (1863) reports a small *Deinotherium* (*Deinotherium bavaricum?*) from the [Upper Miocene] coal seams of Parschlug, Eibiswald, Turnau, Wies, etc., in Steiermark, and a large one, similar to the unnamed species of Lartet, in purely marine deposits. Rachoy (1863) and Stur (1864) found remains of *Deinotherium bavaricum* in the overlying sandstone of the coal bearing Tertiary basin of Leoben in Steiermark.

Cranial Characters, Claudius, 1865.—Claudius (1864 [1865]), from the structure of the auditory labyrinth of *Deinotherium*, shows positively that this genus, like the elephant, belongs to the family of the Proboscidea and among the pachyderms. According to his researches both *Elephas* and *Deinotherium* have a depressed auditory cochlea with less than three convolutions, but notably broad at the base. The planes of the superior and posterior convolutions of the semicircular canals which intersect in the crus commune, form an angle less than 90°, while in *Rhinoceros* and *Tapirus* the cochlea is higher, the angle formed by the superior and posterior convolutions is at least 90°, and the cochlea has hardly more than two convolutions. From the size of the canalis facialis the existence of a trunk may be inferred with certainty. In *Deinotherium* the facialis nerve is led from the inner ear through an elliptical foramen 5‴ long and 2‴ wide. The latter figure, which remains the same for the passage through the tympanic cavity, gives the diameter of the nerve which, from the inner ear outward, penetrates the thin bone in a diagonal direction and thus produces an elliptical opening. The nervus facialis of *Deinotherium* was about the size of the medianus nerve in man, and served like it for the innervation of an enormous number of muscle fibers. In the elephant this canal has the same dimensions: in the tapir it is proportionally much narrower. The stapes is similar in structure to that of the elephant; the incus somewhat smaller (6‴: 4‴); in its morphological relations the labyrinth corresponds perfectly to that of the elephant; similarly the canalis ganglionaris of the cochlea

agrees perfectly with that of the elephant, and consequently shows marked differences from all other mammals in this respect.

Gervais (1864), Falconer (1868).—In Hérault, between Narbonne and St. Chinian, in the freshwater Molasse of Montredon, Gervais (1864) discovered teeth of *Deinotherium giganteum* in the Upper Miocene [Lower Pliocene], as well as fragments of tusks, several bones of manus and pes, a metacarpal, and a phalanx, also an inner ear. In Haute-Garonne, Salaro (1864)[1] discovered a pelvis of *Deinotherium* in which he believed he recognized marsupial epipubic bones, and therefore concluded that it was a monstrous pachyderm-like marsupial related to *Megatherium*, a view also supported by H. von Meyer (1865, p. 1 *et seq.*). Quenstedt (1867) has doubts whether *Deinotherium* should be classed with the pachyderms or the cetaceans, while Carus (1868) would place it between the Sirenia and the Proboscidea. According to Falconer (1868) *Deinotherium* had only two milk molars in both upper and lower jaws—the posterior with three, and the middle one with two transverse crests. The anterior or third remained undeveloped. The two milk teeth were replaced vertically by an equal number of premolars, both of which have two crests. Following these come the three true molars, of which the first has three transverse crests, and the others each two. He divides the Proboscidea into *Mastodon* and *Elephas*, and holds *Deinotherium* for a divergent form of the latter.

Owen (1840) to Lydekker (1876).—Among the more recent works on *Deinotherium* is that of Brandt (1869). He agrees with Owen (1840) and Lartet (1858) that of the three milk molars [Dp 2–4] the anterior one [Dp 2] has no corresponding replacing tooth [P 2], while both the others when they fall out are replaced vertically by two premolars [P 3–4]. The reconstruction of *Deinotherium* which he figures is very similar in form to the elephant, and he also says that *Deinotherium* was a true member (genus) of the family of elephant-like animals, more nearly allied to *Mastodon* than to the elephants, more nearly allied than either *Mastodon* or *Elephas* to many other pachyderms, and related—though slightly—to the Sirenia. Its life and habits resembled those of the elephant. In a separate chapter he lists the various species of *Deinotherium*, with the remark that he will not increase the confusion and divergence of opinions by offering new and unproven views.

Peters (1871) describes a number of *Deinotherium* remains from the highest Miocene deposits of southern Steiermark, which include *Deinotherium giganteum* Kaup, *Dinotherium medium* Kaup, *Dinotherium Cuvieri* Kaup, *Deinotherium bavaricum* H. von Meyer, the latter being only a variety of *Deinotherium giganteum* Kaup. He considers *Deinotherium* as a creature of fluviatile habitat, spending more than half its time immersed in river water. Bachmann (1875) describes and pictures a lower jaw from the Delsberg valley in the Bernese Jura, which he identifies with *Deinotherium bavaricum* H. v. M., and considers as belonging to the pachyderms and not nearly allied to *Manatus*. Zittel (1875) ranks it with the Proboscidea, between *Mastodon* and *Elephas*. Holländer (1877) also classes it with the Proboscidea, but says that the structure of the skull is not unlike that of the Sirenia, and that it was of aquatic habit. In regard to the dental succession in *Deinotherium*, Vacek (1877) fully agrees with Lartet (1858). He considers *Deinotherium* as the direct ancestor of *Mastodon* in the family Proboscidea, and so also does Köllner (1882).

Lydekker (1876) describes a molar from India which he identifies with '*Dinotherium pentapotamicum*' Falconer and later (1880) recognizes a third Indian species, beside *Dinotherium pentapotamicum* and *Dinotherium indicum* Falconer, which he founds on a fragment of lower jaw from Sind and names *Dinotherium sindiense* Lyd. He classes *Deinotherium* with the Proboscidea.

[1] See Sanna-Solaro in Bibliography at close of present Volume I.

The above historical summary is on the authority of Dr. O. Weinsheimer (1883), and the reader is referred to his monograph "Ueber Dinotherium giganteum Kaup," in which he also gives an invaluable Literatur-Verzeichniss (pp. 214–216) of one hundred and fifteen titles, from Réaumur (1715) to Vacek (1882). Weinsheimer then reviews (1883, pp. 217–238) the whole subject of the dentition as observed chiefly in the collections of the museums of Germany. He describes the newly found jaw in the Darmstadt Museum (pp. 238–244) also the cranial and skeletal material in the same Museum (pp. 244–247), and then considers the nomenclature (pp. 247–264) of the following sixteen species described or named up to the year 1880:

	Synonymy *fide* Weinsheimer	Monospecific *fide* Weinsheimer
Deinotherium giganteum Kaup type, Eppelsheim, 1829	= *Deinotherium giganteum*	*Deinotherium giganteum*
Dinotherium cuvieri Kaup type, Eppelsheim, 1832	= *Deinotherium cuvieri*	*Deinotherium giganteum*
Dinotherium medium Kaup type, Eppelsheim, 1833	= *Deinotherium giganteum*	*Deinotherium giganteum*
Dinotherium maximum Kaup type, Eppelsheim, 1831, 1832	= *Deinotherium giganteum*	*Deinotherium giganteum*
Deinotherium bavaricum von Meyer type, Upper Miocene, 1831 Weinsheimer gives a very full discussion with measurements relating to this synonymy	= *Deinotherium cuvieri*	*Deinotherium giganteum*
Dinotherium proavum Eichwald type, 1835, Podolia, Russia	= *Deinotherium proavum*	*Deinotherium giganteum*
Dinotherium secundarium Kaup (ref. Lartet), 1835	= *Deinotherium giganteum* (*fide* Lartet-Weinsheimer)	*Deinotherium giganteum*
Dinotherium königii Kaup type, 1841	= *Deinotherium cuvieri* Kaup *sive D. bavaricum* von Meyer	*Deinotherium giganteum*
Dinotherium minutum von Meyer type (in Bronn, 1841), Upper Miocene, Mösskirch	= *Deinotherium bavaricum* (?)	*Deinotherium giganteum*
Dinotherium australe Owen type, 1843	= *Diprotodon australe*	
Dinotherium angustidens Koch type, Compubay, western India [Cambay (?), western India], 1845	= *Deinotherium angustidens*	*Deinotherium giganteum*
Dinotherium intermedium de Blainville type, 1845	= *Deinotherium bavaricum* (*fide* Lartet, 1858)	*Deinotherium giganteum*
Dinotherium indicum Falconer type, 1845, compare *Dinotherium perimense*, Falconer, 1868, p. 415, Pliocene, Perim Island	= *Deinotherium indicum*	*Deinotherium giganteum*
Dinotherium levius Jourdan type, 1861	= *Deinotherium giganteum* (*fide* Gaudry-Lartet)	*Deinotherium giganteum*
Dinotherium pentapotamiæ Falconer type (MS.), 1868	= *Deinotherium pentapotamiæ*	*Deinotherium giganteum*
Dinotherium sindiense Lydekker type, Middle Miocene, Sind, 1880	= *Deinotherium sindiense*	*Deinotherium giganteum*

Monospecific Error.—The above synonymy is partly based on the erroneous treatment by Weinsheimer of *Deinotherium giganteum* [Lower Pliocene] as a collective species which embraces many of the Miocene stages also. He closes, accordingly, with the following "Schlussbemerkungen" (pp. 280, 281), that in view of the great variation in size of the teeth of *Deinotherium*, and despite the various geologic horizons or layers in which the remains of *Deinotherium* occur, *we have to do with one single European species, namely, Deinotherium giganteum:*

> Hiernach sind also alle Species, welche nach Zähnen oder Kiefern aufgestellt sind, die in Grösse und Gestalt von den dem *Dinotherium giganteum* Kaup zugerechneten nicht mehr abweichen, als von den betreffenden Autoren angegeben wurde, zu einer einzigen Species zusammenzufassen, für welche die von Kaup zuerst gebrauchte Bezeichnung *Dinotherium giganteum* beizubehalten ist. Der Grund der mehr oder weniger grossen Abänderungen in Grösse und Gestalt der Zähne und Kiefer ist, wie wir gesehen, theils auf individuelle, theils auf sexuelle und besonders auch auf Altersverschiedenheiten zurückzuführen. . . . Um dies zu erklären, müssen wir annehmen, dass das *Dinotherium* verschiedener Zeiträume und Landschaften die bedeutenden physischen Veränderungen, welche allenfalls zwischen die Ablagerungszeiten der verschiedenen Schichten der jüngeren Tertiärperiode fallen, überdauert hat, ohne in merklicher Weise von denselben beeinflusst worden zu sein und ohne während der sehr langen Zeitdauer, welche zwischen diesen Veränderungen liegt, die geringste Schwankung seiner Artenmerkmale zu erfahren.

Weinsheimer's Memoir concludes with an invaluable review (pp. 269–280) of the geographic distribution of *Deinotherium* in the provinces of Germany, Switzerland, France, Austria-Hungary, Russia, Greece, and India.

HISTORICAL SUMMARY BY OSBORN, 1883–1934

The historical summary below by the present author relates to some of the chief and more important papers which have appeared since Dr. O. Weinsheimer's review (1883), namely, between 1883 and 1934, but also includes citations from some of the earlier authors, as follows:

Richard Owen, 1840–1868	Charles W. Andrews, 1911	C. Forster Cooper, 1922
Gregoriŭ Stefănescu, 1892–1899	R. Fourtau, 1918	Günther Schlesinger (letter), 1923
E. Kittl, 1908	A. Brives, 1919	Othenio Abel, 1924
Lucien Mayet, 1908	Charles W. Andrews, 1921	R. W. Palmer, 1924

Richard Owen (1840–1868).—First we may revert to Richard Owen (1840–1868), who records (1840, p. 609, 1868, III, pp. 358, 359) the permanent dentition in *Deinotherium* as, $I^{0.0}_{1.1}$; $C^{0.0}_{0.0}$; $P^{2.2}_{2.2}$; $M^{3.3}_{3.3}=22$, and adds three superior and inferior deciduous premolars and one deciduous incisor, namely, Dp 2–4$^{3}_{3}$, Di$^{1}_{1}$.

As regards the tusks, Owen observes (1868, III, p. 359): "The generic peculiarity of the *Dinotherium* is most strongly manifested in its tusks. These, fig. 288, *i*, are two in number, implanted in the prolonged and deflected symphysis of the lower jaw, in close contiguity with each other, and having their exserted crown directed downward and bent backward, gradually decreasing to the pointed extremity. In jaws with molar teeth of equal size, the symphysis and its tusks offer two sizes; the larger ones, which have been found four feet in length, with tusks of two feet, may be attributed to the male Dinothere; the smaller specimens, with tusks of half size, to the female. The ivory of these tusks presents the fine concentric structure of those of the Hippopotamus, not the decussating curvilinear character which characterises the ivory of the Elephant and Mastodon. No corresponding tusks, nor the germs of such, have yet been discovered in the upper jaw of the *Dinotherium*."

1878–1899. THE GIANT DEINOTHERES OF RUMANIA

Stefănescu, 1892.—Professor Gregoriŭ Stefănescu of the University of Bucharest discovered remains of *Deinotherium* far exceeding in size any previously described, to which he gave the name *Dinotherium gigantissimum*, in allusion to Kaup's term *Deinotherium giganteum* of 1829.

There was first discovered in 1878, at Găiceana, district of Tecuciŭ, a molar tooth, probably an M_2, of 120 mm. in length and 120 mm. in width, thus exceeding in size the corresponding tooth of *Deinotherium giganteum*. This molar becomes the type grinding tooth of Stefănescu's new species *Dinotherium gigantissimum*, 1892. It was embedded in yellowish-gray sand (*op. cit.*, 1892, fig. 24) belonging to the Middle Miocene [Lower or Middle Pliocene]. An abbreviated summary of this very important discovery taken from his paper published in 1892 is as follows:

(Stefănescu, 1892, pp. 81, 82): "I received in 1878 a fossil molar tooth found at Găiceana, in the judet (district) of Tecuciŭ. It was the last but one molar of a *Dinotherium*, but it was so large that it could not have belonged to the usual *D. giganteum*, as you may judge from the following dimensions:

Antero-posterior diameter	meters	0.12
Transverse diameter	"	0.12
Height of the crown	"	0.08
Height of the root	"	0.14
Distance between the hills of the crown	"	0.05
Thickness of the hills at their basis	"	0.05

These uncommon dimensions should lead us to look at these remains as belonging to another species than the usual *D. giganteum*, which may be named *D. gigantissimum*."

In the same paper Stefănescu describes a second discovery at Mânzaţĭ of which the following is an abstract (p. 82):

Mânzaţĭ Valley.—In 1890, in the valley of Mânzaţĭ, district of Tutova, was discovered a head of *Deinotherium*, partly removed by visitors, also other remains, preserved as follows:

1. Right branch of lower jaw with five molars, P_3-M_3, *referred* to *D. gigantissimum* [Stefănescu, 1896 (1899), Tab. I].
2. Portion of left branch of lower jaw with two posterior molars, *referred* to *D. giganteum* [Stefănescu, 1895, p. 175].
3. Fragment of right branch of upper jaw with portion of palatal bone and three molars, *referred* to *D. gigantissimum* [Stefănescu, 1896 (1899), Tab. III].
4. Ten ribs, one of which measures 1200 mm., of doubtful reference, Stefănescu, 1892, p. 83.
5. Scapula, measured *in situ*, transverse diameter 1150 mm., Stefănescu, 1892, p. 83.

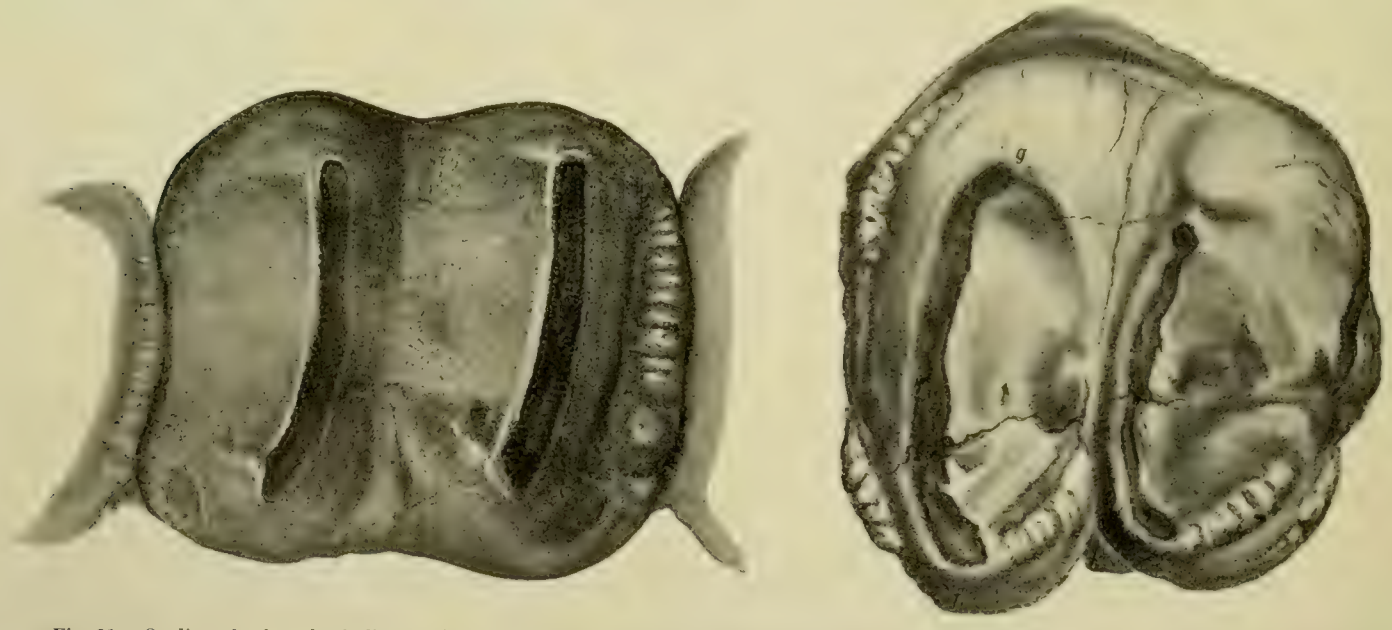


Fig. 61. Outline of referred grinding teeth of *Deinotherium gigantissimum*, after Stefănescu, 1895, Tab. IV and V. Reduced to two-thirds natural size.

A, Second left inferior molar, l.M_2, from Mânzaţĭ.

B, Third left superior molar, l.M^3, from Găiceana.

According to the above descriptions of Stefănescu of 1892, 1895, 1896 [1899], remains referred to *Deinotherium giganteum* and to *D. gigantissimum* occur in the same horizon in the Mânzaţĭ Valley (see Stefănescu, 1892, fig. 24, section through Mânzaţĭ Valley).

Historical Review.—In the Introduction to his paper of 1895 (pp. 173–177) Stefănescu gives a full historical review, "Historique du Dinothérium," of the successive discoveries of remains of *Deinotherium* together with discussions as to the anatomy and affinities of this animal, beginning with Cuvier (1822) and ending with Höllander (1877) and Bieber (1884), namely, from the Tapir gigantesque of Cuvier to the Franzensbad *Deinotherium*.

Description of Dinotherium gigantissimum Stefănescu, 1878, 1892, 1895, 1896 [1899]

Stefănescu's original description of the type molar of *Dinotherium gigantissimum*, "Découverte d'une molaire de Dinothérium en Roumanie," 1878, is not accessible for the present Memoir. The accompanying outlines (Fig. 61) copied from Stefănescu's paper of 1895, Tab. IV and V, exhibit a second inferior molar and a third superior molar referred by him to this species.

In 1895, however, Stefănescu gave a full description of the discovery of *Deinotherium* in Rumania, under the subtitle "Le Dinothérium en Roumanie," in which he mentions the discovery in 1878 of remains at Fundul Boghiții, Găiceana, district of Tecuciŭ, referring them in part to *Deinotherium giganteum* and in part to the largest species which he had named *Dinotherium gigantissimum*.

After reviewing (*op. cit.*, 1895, pp. 173–177) the chief materials found in Rumania referable to *D. giganteum* and to *D. gigantissimum*, Stefănescu describes and figures in detail (pp. 177–195, Tab. I–V) the skeleton and teeth from Mânzați referred to the giant species *D. gigantissimum*, including the successive stages of discovery of: (*a*) Inferior tusk (1889), (*b*) left inferior maxilla and large part of right inferior maxilla, also part of left superior maxilla (1890), two iliæ, two scapulæ, vertebræ, four limbs, eighteen ribs, one tusk, fragments of cranium, débris of teeth and of different bones (1890). He concludes (p. 183): "Comme on le voit, j'ai eu le bonheur de trouver à Mânzați le squelette presque complet de ce colossal Dinothérium; je n'ai trouvé cependant que *deux vertèbres*, mais il est probable qu'on trouvera aussi les autres." The bones were found within a space 10 m. in length and 3 m. in breadth, 30 sq. m. in all. Stefănescu indicates the following conditions regarding depth (*op. cit.*, p. 183): "Ces faits prouvent ou que le Dinothérium de Mânzați est mort envasé dans un endroit bourbeux, en cherchant à y boire ou à s'y rafraîchir, ou que, après sa mort, il a été presque aussitôt recouvert d'une couche de limon, qui a empêché le corps de se décomposer à l'air, ou d'être la proie des animaux féroces qui eussent dispersé les os et y eussent laissé la trace de leurs dents aiguës."

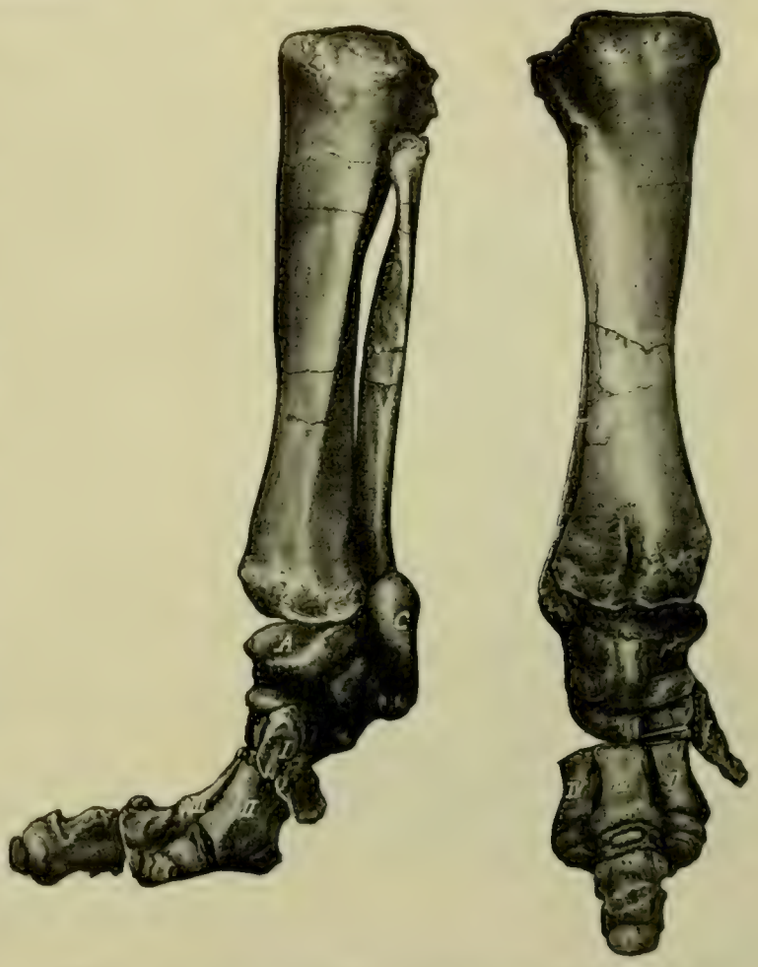


Fig. 62. Front and side views of tibia and pes of *Dinotherium gigantissimum*, after Stefănescu, 1899, Tab. IV. This retouched drawing is one-twelfth natural size.

The following details are important: (1) In this excavation all the parts belong incontestably to one individual; (2) nearly all the bones were found in normal connection; (3) no doubt remains that *Deinotherium* had but three digits [D.II, III, IV—Fig. 62], with a vestigial D.I in the pes; the tarsal and metatarsal bones are more or less cylindrical.

From the detailed measurements of all these parts, we may extract the following: Found with the skeleton from Mânzaţĭ, a second left inferior molar, l. M_2, diameters, ap. 111 mm., tr. at protolophid 90 mm., index 81. Found at Găiceana, a left third superior molar, l. M^3, diameters, ap. 107 mm., tr. 105 mm., index 98.

Comparative Diameters and Lengths of Grinders and Limbs[1]

	Tapir gigantesque Cuvier	*Deinotherium giganteum* Kaup	*Dinotherium indicum* Falc. and Pilgrim	*Dinotherium gigantissimum* Stefănescu Mânzaţĭ	*Dinotherium gigantissimum* Stefănescu Găiceana
Anteroposterior diameter of M_2	85	81	99	111	
Anteroposterior diameter of M_3		91		114	107
Space occupied by five inferior molars, P_3-M_3		453		540	
Length of inferior tusks				560	
Length of tibia (cf. Fig. 62)		920e		930–976	
Height of tarsus (cf. Fig. 62)				210	
Total length of median Mts. III				152	

The author concludes (1895, p. 197):

Deuxième molaire de la mâchoire inférieure [second inferior molar, M_2]	Tapirus giganteus de France Cuvier	Dinoth. giganteum d'Eppelsheim Kaup	Dinothérium Indicum de Périm Falconer	Dinothérium gigantissim. de Mânzaţĭ Stefănescu
Diamètre antéropostérieur	0,085	0,081	0,099	0,111
Diamètre transversal de la colline postérieure (à la base)	0,073	0,072	0,088	0,097
Diamètre transversal de la colline antérieure (à la base)	0,075	0,076		0,099

Dernière molaire de la mâchoire supérieure [third superior molar, M^3]	Dinothérium giganteum d'Eppelsheim	Dinothérium de Mânzaţĭ	Dinothérium de Găiceana
Diamètre antéropostérieur	0,091	0,114	0,107
Diamètre transversal de la colline postérieure (base)	0,084	0,107	0,104
Diamètre antéropostérieur de la colline antérieure	0,091	0,117	0,117

The author observes in his paper of 1896 [1899], p. 127, as follows: "Si, d'une part, nous considérons les dimensions de beaucoup plus grandes des dents du Dinothérium Gigantissimum, en comparaison avec celles des autres Dinothériums connus, et surtout avec celles du Dinothérium Giganteum, si, d'autre part, nous prenons en considération l'existence d'un bourrelet crénelé continu à la base de toutes les molaires de la mâchoire supérieure, et surtout de la première molaire, ce qu'on ne trouve pas de la sorte chez les autres espèces, nous pouvons, à bon droit, regarder le Dinothérium de Mânzaţĭ comme appartenant à une autre espèce, et conséquemment, regarder comme étant assez justifiée, la creation de l'espèce *Gigantissimum*."

[1]Limb measurements of *D. bavaricum* of Franzensbad inserted below (pp. 100, 102).

1908. FIRST RECONSTRUCTION OF THE SKELETON OF DEINOTHERIUM BAVARICUM

Upper Miocene of Franzensbad, Bohemia

E. Kittl, 1908.—The first description of this skeleton is that of Kittl in his article "Das Dinotheriumskelett von Franzensbad im k. k. naturhistorischen Hofmuseum" (1908). In describing the skeleton, Kittl remarks that this almost completely restored skeleton of *Deinotherium* arouses wide attention in the Vienna Museum because the only other skeleton which appears to be nearly as complete is in the University Museum of Bucharest. He speaks of the abundance of scattered skeletal materials in sand and gravel deposits of western Europe, chiefly of fluviatile and flood-plain origin, in contrast to the rarity of entire skeletons, in fact, an entirely complete skeleton had never been discovered up to 1908. The two most complete discoveries of this animal are those made near Franzensbad in Bohemia and near Mânzaţĭ in Rumania, the former exhibited in Vienna, the latter in Bucharest.

These animals belong to different species and are widely distinguished by their size. The Franzensbad *Deinotherium* attains the dimensions of a half-grown elephant, whereas the Rumanian skeleton [*D. gigantissimum*] equals in size the largest of the living elephants. Its specific distinctions, however, rest less upon size than upon the structure of the grinding teeth; the condition of wear of the teeth in both skeletons indicates prolonged use.

Fig. 63. Mounted skeleton of the Upper Miocene *Deinotherium* of Franzensbad, Bohemia, in the Royal Museum of Natural History, Vienna, referred to *Deinotherium bavaricum*. After photograph kindly furnished the present author by Prof. Othenio Abel of Vienna.

Comparing the [Upper Miocene] Franzensbad Deinothere with other skeletons, it appears to belong to a small, perhaps to the smallest, species of the genus *Deinotherium*, whereas the Rumanian skeleton [*D. gigantissimum*] belongs to the largest variety of this genus. Between these two extremes we can range a series of intermediate size. It is the middle-sized *Deinotherium* which was first observed; as early as 1812 Cuvier designated them as large tapirs owing to the resemblance of the back teeth to those of the tapir; in 1833 [1829] they received the generic name *Deinotherium* with reference to their very large size. The discovery of a complete skull of *Deinotherium* in 1836 in a sand pit near Eppelsheim south of Mainz enabled us to understand these animals more clearly. It was, however, through the skeletal structure that the Deinotheres were first compared with the trunk-bearing pachyderms, i. e., elephants and mastodons, to which they have the greatest number of resemblances. The most striking differences of the genus *Deinotherium*, as contrasted with other proboscideans, lie in the structure of the skull and especially of the teeth; above all in the structure of the lower jaw which is strongly elongated and sharply bent downwards, the great incisor tusks bending backwards and not forwards. Their second distinction is in the structure of the grinding teeth in which two sharp transverse crests appear, except in the middle back tooth, M^2-M_2, which is trilophodont. In the permanent dentition of the Deinotheres there are five grinding teeth in each jaw, namely, P^3–P_3, P^4-P_4, M^1-M_1, M^2-M_2, M^3-M_3, in all twenty grinders.

The Franzensbad skeleton, attaining a length of 3.2 m. (=10 ft. 6 in.) and a height of 2.5 m. (=8 ft. 2½ in.), is referred to the smallest species *Deinotherium bavaricum*. It was found in a cleft of calcareous rock near Franzensbad in the year 1883. The bones belonging to it were partly complete, partly broken into numerous fragments, the assembling of which occupied a long time. The complete skull with a lower jaw, several of the large bones of the extremities, numerous vertebræ and foot bones, and a large number of ribs were modeled. For this purpose fossil bones and models were employed from the Vienna and other museums, also the skeleton of an elephant as an object of comparison.

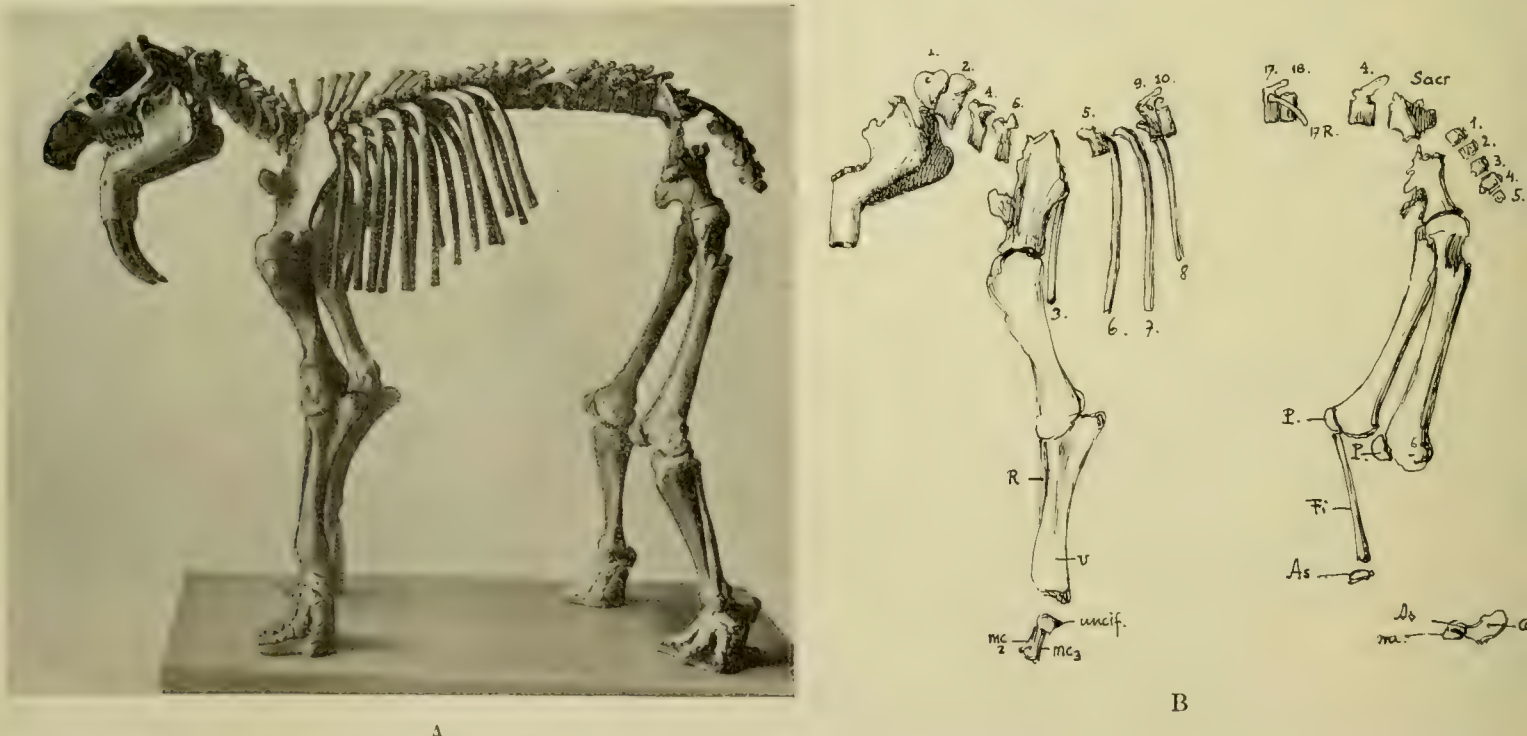
Referring to the stature of the species of *Deinotherium:*

Deinotherium bavaricum (or *D. cuvieri*) includes animals of the smallest size, Middle Miocene, second Mediterranean layer.

Deinotherium levius (or *D. medium*) includes animals of middle size, generally distributed; *D. giganteum*, animals of the larger size, Pliocene, Congerienschichten and Belvedereschotter.

Comments on the Deinotherium bavaricum Skeleton of Franzensbad. Miocene

Schlesinger, 1923.—The original materials included in this mount are shown in figure 64B. The mount as it appears in the Vienna Museum of Natural History, with the iron-work removed, is shown in figure 64A.



A B

Fig. 64. Deinotherium bavaricum of Franzensbad. Original and Restored Portions of Skeleton as mounted in the Vienna Museum

From notes and observations kindly forwarded by Dr. Günther Schlesinger (letter, Vienna, December 17, 1923) a modified description and figure of the skeleton of *Deinotherium bavaricum* are presented herewith.

A, Photograph, side view of skeleton as mounted, with the iron uprights removed by retouching of the photographic plate.

B, Sketch furnished by Doctor Schlesinger showing the original parts of the skeleton preserved.

(1) Original Parts.—Lower jaw without incisor teeth, atlas, axis, cervicals 2, 4, dorsals 5, 9, 10, lumbars 17, 18, 22, parts of sacrum, caudal vertebræ. Of left forelimb: Left scapula, left humerus without articular end, ulna, distal end of radius and upper proximal end, unciform, and metacarpals II, III. Of right forelimb: Scapula, ulna, radiale of the carpals, ulnare, trapezoid, magnum, metacarpals I, III, IV. Of the hindlimb: Pelvis, femur of right and left side, left and right patellæ, right fibula, left calcaneum, right and left astragali, left navicular. (2) Parts Restored in Plaster.—Sacrum partly restored. Cervicals, dorsals, and lumbars apparently too abbreviate. Skull and dorsal spines partly restored. (3) Errors in Mounting.—Scapula and pelvis apparently too upright; possibly the restoration of the extremities elongates them too much.

Measurements by Professor Abel (letter, January 13, 1926).—Length of humerus 81.5 cm., of ulna 80 cm., of femur 105.5 cm., and of mandible 63 cm.

It was at the request of the present author that further information regarding the original materials and the restored portions of this skeleton was kindly sent by Dr. Günther Schlesinger in a letter dated Vienna, December 17, 1923, as follows:

Ihren Brief vom 15 November 1923 mit Dank bestätigend beeile ich mich, die verlangten Photographien zu übermitteln. Durch die Liebenswürdigkeit unseres Kollegen Prof. Schaffer vom Naturhistorischen Museum ist es mir möglich, Ihnen zwei Aufnahmen in 3 Kopien zu übermitteln [Fig. 64A, B]. . . . Meine näheren Angaben über die Verteilung von Originalstücken und Ergänzungen in Gips werden Sie allerdings über das Skelett sehr enttäuschen. Wirkliche Fossilreste sind nur: Mandibel (ohne Incisoren), Atlas, Epistropheus, 2, 4. Halswirbel, 5, 9, 10–17, 18, & 22, Rumpfwirbel, das Sacrum und der Schwanz, ferner von der linken Vorder-Extremität Scapula, Humerus (ohne Gelenkskopf), Ulna, distales Ende und oberstes proximales Ende des Radius, Unciforme und Metacarpale 2 & 3. Von der rechten Vorder-Extremität sind original: Scapula, Ulna, Radiale, Ulnare, Trapezoid, Magnum, und Metacarpale 1, 3, & 4. Von den Hinter-Extremitäten ist das Becken original ferner: Femur sin. et dext., Patella sin. et dext., Fibula dext., Calcaneus sin., Astragalus sin. et dext., Naviculare sin. *Alles andere ist Gips.*

Die Montierung des Skelettes halte ich mit Ihnen für zu hoch. Der Fehler dürfte daher gekommen sein, dass das Sacrum nur zum Teil vorhanden ist, und die Ergänzung der Wirbelkörper anscheinend zu kurz ausgefallen ist. Auch scheinen mir Schulterblatt und Becken zu steil zu stehen. Vielleicht ist auch bei der Gipsergänzung der Extremitätenknochen etwas zu viel an Länge herausgekommen. Allerdings dürfte dies kaum erhebliche Werte ausmachen.

Abel, 1924.—At the request of the present author, Prof. Othenio Abel in a letter dated Vienna, January 8, 1924, kindly supplemented in somewhat more detail the information conveyed by Doctor Schlesinger, accompanying it with a new and more direct frontal photograph (see Fig. 63):

[1. *Original and restored parts*] Vor allem dürfte es für Sie wichtig sein, zu erfahren, welche Knochen erhalten und welche ergänzt sind. Ich erfuhr gestern, dass Dr. Schlesinger Ihnen bereits geschrieben hat, wovom er mich nicht verständigt hat; so weiss ich nicht, ob er Ihnen diese Liste mitteilte. Ich habe sie heute Vormittag aufgenommen und zwar sind von diesem Skelette erhalten:

Unterkiefer (ohne Incisivem)
Atlas
Epistropheus
4 Halswirbel
6 "
5 Brustwirbel (nur Zentrum)
9 " "

Linke Körperseite:
2 Rippe
3 "
6 "
7 "
8 "
17 "

Scapula
Humerus
Radius
Ulna

Unciforme

Metacarp. II, III
Becken (sehr fragmentarisch)
Femur
Patella

Astragalus
Calcaneus
Naviculare

10 Brustwirbel (mit Neurapophyse)
17 " (nur Zentrum)
18 " "
4 (vorletzter) Lendenwirbel (nur Zentrum)
Sacrum
1 bis 5 Caudalwirbel

Rechte Körperseite:
1 Rippe
3 " (nur Oberende)
4 "
5 "
7 " (nur Oberende)
10 "
11 "
12 "
Scapula

Radius (nur untere Epiphyse)
Ulna
Ulnare
Radiale
Unciforme
Magnum
Metacarp. I, III, IV

Femur
Patella
Fibula
Astragalus

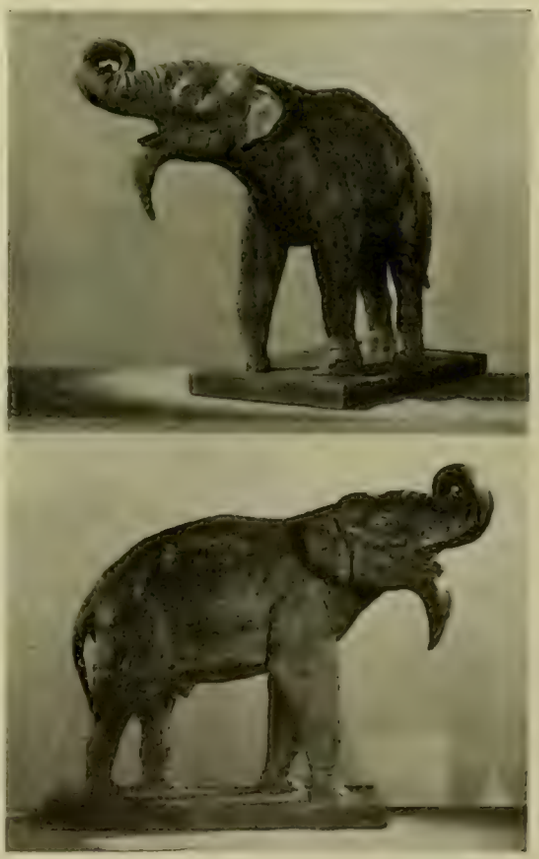


Fig. 65. *Deinotherium bavaricum* in the Vienna Museum. Model by Othenio Abel (1932), about one-fiftieth natural size.

[2] Dimensionen: Distanz vom Unterende des linken Unterkiefers (Angulus) bis zum
Vorderrande der Stosszahnalveole: 66 cm. [=2 ft. 2 in. approx.]
Länge des linken Humerus: 75 cm. [=2 ft. 5½ in. approx.]
Länge des linken Femur: ca. 100 cm. [=3 ft. 3½ in. approx.]

[3] Was die Rekonstruktion des Skelettes anbetrifft, so scheint mir vor allem ein Fehler darin zu liegen, dass die Richtung der Neurapophysenachsen fächerförmig divergiert, was unmöglich ist. Ferner steht das Sacrum viel zu hoch über der Standfläche. Es muss tiefer herabgesenkt werden. Die Stellung ware etwa so wie auf meiner Rekonstruktion des Dinotherium giganteum, von der ich Ihnen eine Photographie beischliesse (vgl. 'Lebensbilder aus der Tierwelt der Vorzeit,' Fig. 82, pag. 91). Sodann steht die linke Scapula ganz unrichtig, weil zu weit nach einwarts gedreht und ausserdem ist die Höhenlage zum Thorax unrichtig angenommen, wie aus dem Vergleiche mit dem rezenten Elefanten hervorgeht. Wenn Sie meine Pause der Photographie mit dem Skelette eines Elefanten in den 'Recherches sur les Ossemens fossiles,' T. I, Pl. 1, pag. 204, zur Deckung zu bringen versuchen, mit dem die Photographie des Dinotherium bavaricum in der Grösse gut übereinstimmt, so werden Sie sehen, dass sich Dinotherium bavaricum in überraschender weise als in den allgemeinen Proportionen durchaus wie ein rezenter Elefant verhält und sich von Bunolophodon etc. unterscheidet. Darum habe ich auch in meiner Rekonstruktion des D. giganteum, das sich von D. bavaricum nur unwesentlich, abgesehen von der Grösse und einigen anderen unbedeutenderen Merkmalen unterscheidet, den lebenden Elefanten zum Vorbilde genommen.

[4. Habits] Ich halte Dinotherium für einen Laubfresser, der seine Stosszähne zur Nahrungsaufnahme nur insoweit verwendete, als er mit ihrer Hilfe Baumäste abbrach, wie ich dies in meiner Rekonstruktion andeutete. Ausserdem hat Dinotherium seine Stosszähne wohl auch als Waffen verwendet, hat aber damit kaum den Boden erreichen können, ebensowenig wie ein Elefant in der *Standstellung* dies zu tun vermag (ich denke an den indischen Elefanten). Dinotherium ist selbst verständlich etwas ganz anderes als Mastodon oder Bunolophodon hinsichtlich seines Körperbaues. Unter den fossilen Proboscidien der Tertiärzeit kommt es meines Erachtens dem Elefanten der Gegenwart am nächsten.

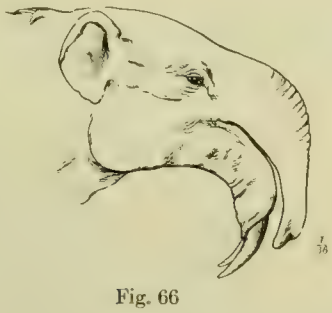


Fig. 66

Fig. 67

Fig. 66. Restoration of the head of *Deinotherium* modified from Gregory and Osborn (Osborn, 1910.346, p. 247). It will be observed that the proboscis is drawn much shorter than that in the restoration of Abel (Fig. 67); this short proboscis is probably erroneous.

Fig. 67. Restoration of *Deinotherium*, after Othenio Abel, "Lebensbilder aus der Tierwelt der Vorzeit," 1922, p. 91, fig. 82, showing the animal with a hairy coating. It will be observed that the proboscis is drawn much longer than in the Osborn-Gregory restoration (Fig. 66); this is probably correct.

1921–1924. RECONSTRUCTION OF SKULL OF DEINOTHERIUM GIGANTEUM

British Museum. W. D. Matthew, September, 1920.—The skull of *Deinotherium* restored and figured by Kaup is complete and very little crushed. The occiput pitches forward almost horizontally, with a great nuchal pit. The upper tusks are certainly absent. The breadth and the overhang of the nasal region are mostly natural.

Andrews, 1921.—The original skull purchased from Kaup by the British Museum was carefully described by Dr. Charles W. Andrews in the year 1921 (p. 532) as follows:

> The skull of *Dinotherium* is, in many respects, one of the most remarkable known. Although fundamentally its characters are clearly Proboscidean, nevertheless it differs widely from the skulls of the other members of the group and, indeed, in some respects from that of any other mammal. In the true Elephants and Mastodons the peculiar form of the skull is mainly due to the enormous development of cellular bone in the occipital region, increasing the area available for the attachment of the muscles necessary for the support of the heavy trunk and tusks.

In *Dinotherium*, although the upper tusks are wanting, the trunk, judging from the large size of the nasal opening, must have been enormous, and the weight of the head was further increased by the great deflected mandibular symphysis with its large tusks. In this case, however, the area for the attachment of the supporting muscles was supplied by the widening out of the occipital surface, which was further increased laterally by the extension outwards of the squamosals. Little or no cellular bone seems to have been developed, the occipital surface above the post-tympanic flanges being nearly flat except for the depression for the nuchal ligament. This flattening of the occiput, combined with its forward inclination, must have made it possible for the animal to move its head up and down through a large arc, a movement perhaps connected with the use of the downwardly directed lower tusks. The great width of the proboscis, probably rendered possible by the absence of upper tusks, led to the widening out of the skull in the orbital region, producing the shelf-like projection of the maxillæ above noticed. The great width of the glenoid surface for the mandible is a peculiarity for which it is difficult to account, unless it is correlated with the general widening of this region of the skull.

The skeleton of *Dinotherium* is still very imperfectly known, but such bones as have been described show that the animal must have been quite Elephantine in structure and appearance except as to its head, the legs being pillar-like and the neck short. A femur probably associated with the skull above described measured 150 cm. in length. The numerous speculations as to the appearance and habits of *Dinotherium* have been summarized by de Blainville and Stefănescu in their works referred to above. Most writers seem to suppose that the animal was chiefly fluviatile and aquatic in its habits, but there appears to be no good reason for believing that it was more so than the Elephants.

India. Palmer, 1924.—In the Memoirs of the Geological Survey of India there appears an account by R. W. Palmer of an incomplete skull of *Deinotherium* which was published after his death in October, 1922, and the paper of 1921 by Charles W. Andrews, cited above, and that of 1922 by C. Forster Cooper, cited below, were therefore not consulted (see Palmer, Nature, Oct. 25, 1924, p. 624):

The specimen described is an incomplete fragment of a skull showing the basal surface from the condyles to the pterygoid region. The anatomical features shown do not differ markedly from those described by the late Dr. Andrews for the celebrated skull of *Dinotherium giganteum* in the British Museum, but the new specimen being in better condition, certain points are more clearly established. With regard to the question of the validity of the Indian species *D. indicum and D. pentapotamiæ*, the author concludes that they cannot be upheld and that they are both to be referred to the European form *D. giganteum*. This agrees with the views already published by Forster Cooper which were the outcome of a study of material from Baluchistan.

(Palmer, 1924.1) Found in the Lower Chinji Sandstone, Lower Pliocene (*fide* Pilgrim, 1913).

1911–1919. DISCOVERY OF DEINOTHERES IN AFRICA

Deinotherium hobleyi is the first species of the genus *Deinotherium* described from the continent of Africa; no mention is made by Fourtau (1918) of the presence of *Deinotherium* in the Lower Miocene of Moghara, although the Moghara locality (Fourtau, *op. cit.*, p. 91) is described as certainly the richest in northern Africa in the remains of mastodonts, containing the types of '*Mastodon*' [=*Rhynchotherium(?)*] *spenceri* and of '*Mastodon*' [=*Trilophodon*] *angustidens* var. *libyca*, as described by Fourtau. In fact, Fourtau remarks (*op. cit.*, p. 91):

Mais il est un fait assez bizarre à constater, c'est l'absence totale de restes de *Dinotherium*, le compagnon habituel des mastodontes miocènes. Il semblerait donc que ces animaux ne sont pas d'origine africaine, et que les restes signalés dans l'Ouganda et en Ethiopie [Footnote: 'E. Haug.—Traité de Géologie, tome II (2), p. 1727.'], à des horizons bien supérieurs, proviendraient d'une migration postérieure à l'apparition des *Dinotherium* en Asie et en Europe.

Sir Harry Johnston independently supports the African origin of the Deinotheres and in 1925 writes to Osborn as follows:

Johnston (letter, March 16, 1925).—You assign to the Dinotheria a 'European and Asiatic' habitat, but unless I have been grossly misled I rather fancy that the discoveries of Hobley, Fraas and one or two other Germans investigating Upper Egypt have shown the Dinothere group of Proboscideans to have originated in Egypt or Equatorial East Africa. Hobley discovered remains of pygmy Dinotheria in the Miocene formations lying east of the Victoria Nyanza—some such year as 1908. When I was in Germany just prior to the War I was shown specimens collected by German palæontologists

from Stuttgart and Munich, which, though fragmentary, certainly seemed to point to a primitive Dinotherium. These, I understood, were discovered in Upper Egypt [i. e.,Tébessa]. They or I may have been wrong, however, and it is possible that Hobley's East African Proboscideans may not have been Dinotheres. But I think their statements are worth your investigation.

ANDREWS, 1911.—Seven years previous to Fourtau's paper and twenty-eight years after the publication of Weinsheimer's history, Charles W. Andrews recorded (1911.1, p. 35, Abstract, Proc. Zool. Soc. London) the discovery near Karungu, British East Africa, of a species which he named *Dinotherium hobleyi*, after C. W. Hobley, Commissioner of Mines in British East Africa.

(Andrews, *op. cit.*, p. 35): The specimens described were sent to the British Museum by Mr. C. W. Hobley, Commissioner of Mines for British East Africa. They included portions of the mandible with teeth, a calcaneum, and a patella of a small species of *Dinotherium* nearly allied to *D. cuvieri*, from the Lower and perhaps Middle Miocene beds of France. The new species, which he [Andrews] proposed to call *Dinotherium hobleyi*, differed from *D. cuvieri* in several particulars—e. g., the inner anterior column of pm 3 was more distinctly developed, and the talon of M_3 had a distinct tubercle on its inner side.

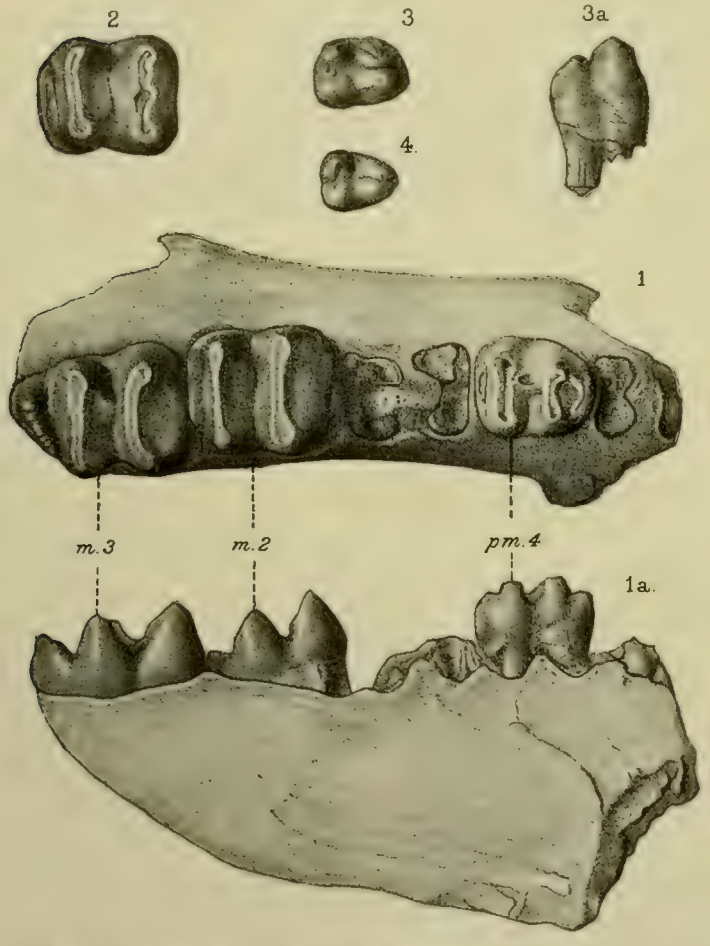


Fig. 68. Original type figure of *Dinotherium hobleyi* Andrews, 1911.2, Pl. XLVIII, figs. 1, 1a, one-third natural size. From near Karungu, British East Africa.

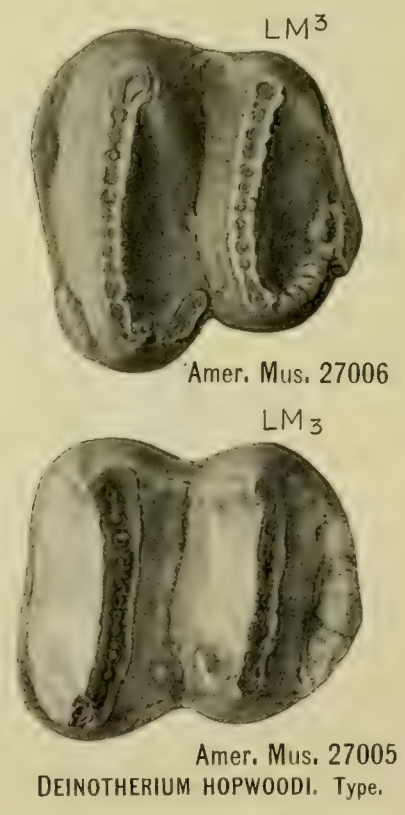


Fig. 68a. Type third superior and inferior molars (casts Amer. Mus. 27006, 27005) of *Deinotherium hopwoodi* sp. nov., from Olduvai, near the southeast shore of Lake Victoria, regarded as of Middle Pleistocene age. One-half natural size. Collected by Mr. Arthur T. Hopwood of the British Museum. Observe especially the subdivision of the summits of the crests into 14 to 16 conelets. Originals (Brit. Mus. M. 14118, M. 14119 respectively). See page 117 below for description.

The same author published (1911.2, p. 943) a full description of *Deinotherium hobleyi*, from which the following has been extracted:

. . . from the neighbourhood of Karungu on the east side of Lake Victoria Nyanza. Most of the specimens are indeterminable fragments, probably picked up on the surface, but in addition to these there are some beautifully preserved teeth with a portion of the mandible (Pl. XLVIII, figs. 1, 1a) of a small species of *Dinotherium;* a small imperfect Proboscidean calcaneum (fig. 5), a patella, and some other fragments probably belong to the same animal. . . . In size and, on the whole, in the pattern

of the teeth this Dinotherium is very similar to *D. cuvieri* Kaup, which is from the lower and middle Miocene of France, being apparently especially characteristic of the Burdigalien horizon. Detailed comparison however shows some differences. . . . These differences, coupled with the remoteness of the localities in which the two forms are found, seem to justify the establishment of a new species for this East African animal and I propose that it shall be called *Dinotherium hobleyi* Andrews.

Brives, 1919.—A. Brives notes in 1919 (p. 90) the discovery of a single tooth of *Deinotherium* in the sands of Djebel Kouif near Tébessa, which he refers to the Lower Miocene *Deinotherium cuvieri* and describes as follows:

Le Djebel Kouif est un vaste plateau de 16 à 18 kilomètres de tour d'une altitude moyenne de 1150 à 1200 ^{m}, qui est situé près de la frontière tunisienne à 27 kilomètres au Nord-Est de Tébessa. . . . C'est dans ces sables qu'à été trouvée une belle dent de *Dinotherium* en parfait état de conservation. C'est la première fois que cet animal monstrueux est signalé dans l'Afrique du Nord et ce fait a une importance capitale, car il permet de fixer d'une manière précise l'âge des sables qui le renferme. . . . Les seuls débris organiques trouvés dans les assises consistaient en fragments de troncs d'arbres silicifiés dépourvus d'écorce et de racines. . . . Au col de Beccaria, Ph. Thomas a recueilli et cité: *Araucarioxylon xgyptiacum* Krauss, *Bambusites Thomasi* Fliche, *Palmoxylon Cossoni* Fliche, *Ficoxylon cretaceum* Schenk, *Acacioxylon antiquum* Schenk, *Jordanta tunetana* Fliche, *Nicolia xgyptiaca* (?) Unger. . . . La présence du *Dinotherium* ne laisse plus aucun doute sur l'âge miocène de ces dépôts; il reste à préciser maintenant si ces assises sont du Tortonien ou du Pontien. . . . La dent que je présente est identique comme dimensions à un exemplaire de *Dinoth. Cuvieri* des faluns de Maine et Loire . . . La dent du Kouif est une 2^{e} molaire supérieure; elle est presque carrée (5 centimètres ½ au collet), les crêtes sont légèrement usées, les racines manquent.

Leakey, 1932–1934.—To the north of Olduvai, about 300 km., is Karungu, the type locality of *Deinotherium hobleyi* (Fig. 56, 22), on the east shore of Lake Victoria. About 30 km. distant from this was found by Dr. L. S. B. Leakey, on the islands in the Kavirondo Gulf, a tooth of a Deinothere probably referable to the Pleistocene species *D. hopwoodi*, associated with remains of *Homo kanamensis* of Kanam, East Africa (see footnote, p. 85, of present Memoir).

1922. REVISION OF THE DEINOTHERES OF INDIA

Forster Cooper, 1922.—In the Proceedings of the Zoological Society for the year 1922, C. Forster Cooper published the following observations on the Deinotheres discovered in the Lower Miocene Bugti beds of Baluchistan, also in higher geologic levels.

Middle Pliocene, Perim Island, is the type geologic level of Falconer's *Dinotherium indicum*, 1845; its specific characters lie in the shape of the jaw, there being no difference from *D. giganteum* in the teeth excepting a greater thickness of the enamel. Falconer (1868, p. 415) apparently refers to the same species as *D. Perimense*, a name nowhere defined.

Upper Pliocene, Attock. Falconer mentioned (MS. labels) a smaller variety from Attock but did not definitely name it; this smaller variety was subsequently named *Dinotherium pentapotamiæ* by Lydekker in 1876, but in 1886 he united this species as a synonym with *D. indicum*, regarding the differences as individual variations.

Middle Miocene, Salt Range, Sind, India, is the type geologic horizon of *Dinotherium sindiense* Lydekker, 1880; regarded by Lydekker (1880, p. 196) as distinct from *D. pentapotamiæ;* the type (Lydekker, *op. cit.*, Pl. xxxi, fig. 4) regarded by Forster Cooper as too fragmentary to afford adequate evidence of the specific distinctions.

Lower Miocene, Bugti beds, Bugti Hills, Baluchistan, is the type geologic level of *Dinotherium náricum* Pilgrim, 1908. (Pilgrim, 1908, p. 157): "It differs very markedly from the other known species." Subsequently, however (1912, p. 16), Pilgrim withdrew the name *D. náricum* and substituted the name *D. pentapotamiæ* [*indicum*] var. *gajense.*

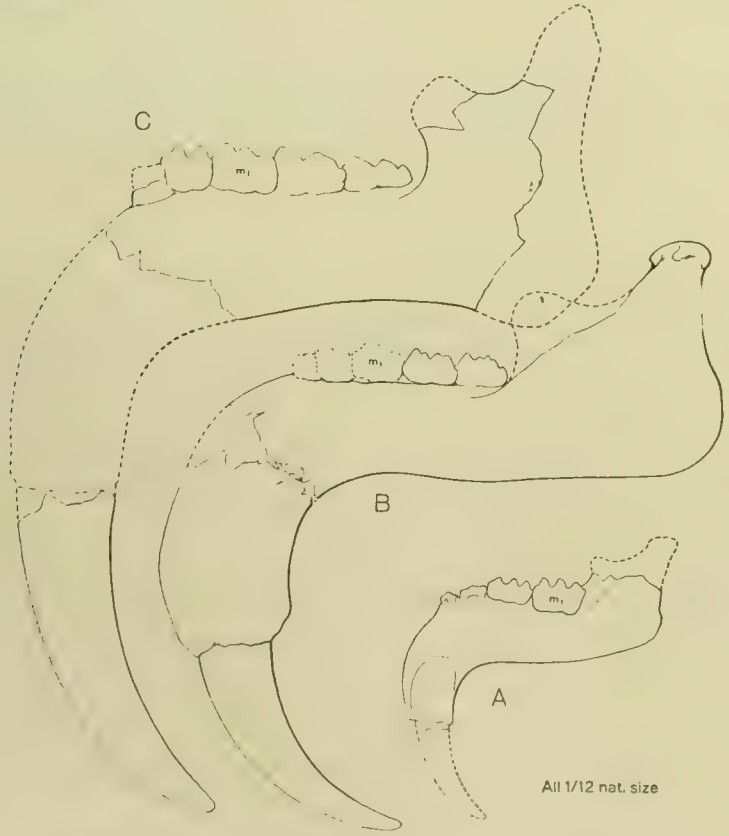
Forster Cooper (1922, p. 621, 622) considers that the characters assigned by Falconer and Pilgrim, and the published figures, lie within the limits of variation of *D. giganteum* of Darmstadt, e. g., Brit. Mus. collection No. M.3494. In this Cooper agrees with Weinsheimer (see p. 94 of the present Memoir).

Bugti Beds (Forster Cooper, 1922, pp. 622–624).—The material of the present collection from the Bugti beds is, as is the common experience, both scanty and fragmentary, and consists only of part of a lower jaw and some separate upper and lower teeth. The lower jaw (text-figs. 8 & 9) belongs to a small form, and in size and structure compares closely with *D. hobleyi* [Footnote: 'Andrews, P. Z. S. 1911.']. The third ridge of the last molar is not parallel to the front ones, but slopes at an angle similar to that found in *D. hobleyi* and *D. lævius*. Of the separate teeth, none shows any great difference from specimens of European forms with which it has been compared. An upper molar, probably a second, is here figured (text-fig. 10). There is nothing in it which can be construed as a 'longitudinal ridge,' nor is there anything in the nature of a 'cusp blocking the valley' which has not been found within the range of variation of European specimens. A third upper premolar (Pl. iv, fig. 6) is also figured to show the separation of the inner cusps said to be characteristic of the Indian forms, but which, as has just been stated above, occurs also in *D. giganteum*. The remaining teeth in the collection are not distinguishable from the smaller forms from Europe, and call for no comment except for three specimens.

Comparative measurements (pp. 625 and 626) of the lower and upper grinding teeth of *Deinotherium* sp. and of *Trilophodon angustidens* from the Bugti beds of Baluchistan, from Chevilly (Lower Miocene), and from Sansan and Simorre (Middle Miocene) of France are given, and the following conclusions are reached.

Summary.—The Proboscidea of the Bugti beds of Baluchistan include *Trilophodon angustidens* [=*cooperi* Osb.] and a small *Deinotherium*. The Indian *T. angustidens* is a small animal, more primitive than the Middle Miocene forms of Sansan, for which the name *T. angustidens palæindicus* may be retained.

The *Deinotherium* resembles the smaller European Deinotheres, also the *D. hobleyi* of Africa. It is doubtful in our present state of knowledge whether the Indian Deinotheres are separable from the European.



Progressive Increase in Size of Mandible of Deinotherium

Fig. 69. Outline to same scale, namely, one-twelfth natural size, of:

C, Adult lower jaw of *Deinotherium gigantissimum* as partly restored by Stefănescu, after Stefănescu, 1899, Tab. I.

B, Adult lower jaw of *Deinotherium giganteum*, after Kaup, 1835.1, Add Tab. I, fig. 5.

A, Juvenile lower jaw of *Deinotherium cuvieri* ref., after Lartet, 1859, Pl. xiii, fig. 4.

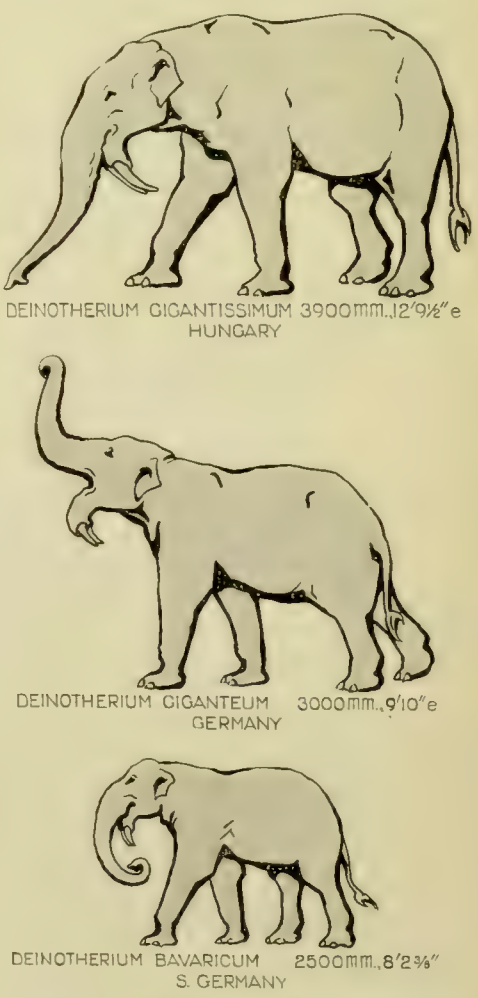


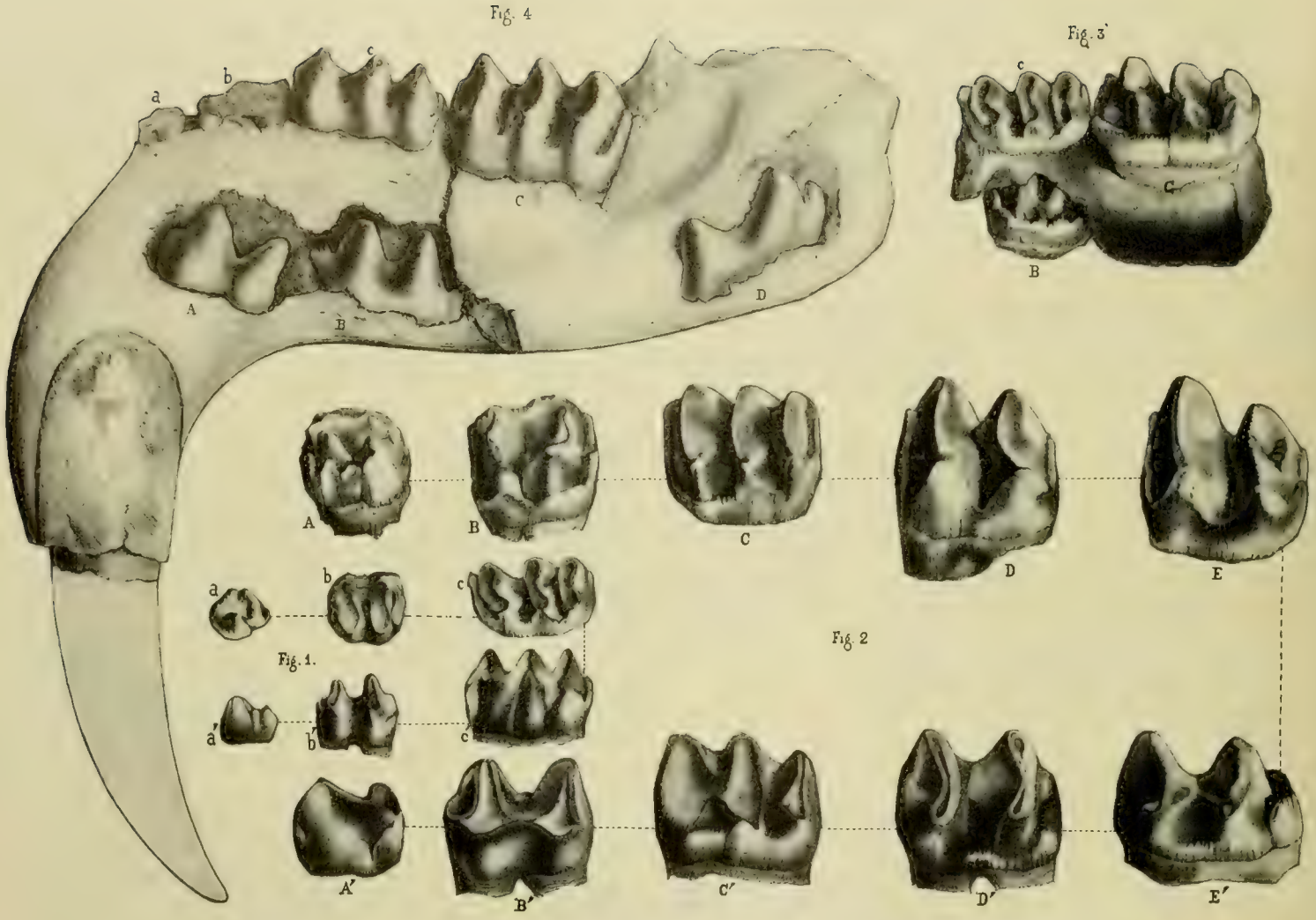
Fig. 70. Restorations (1932) by Margret Flinsch, under the direction of Henry Fairfield Osborn. One-hundredth natural size.

These are based on the known skeleton of *Deinotherium bavaricum* and the incomplete skeleton of *D. gigantissimum*.

1908–1925. SPECIFIC REVISION OF THE DEINOTHERES OF EUROPE

MAYET, 1908, PP. 199–206.—This valuable specific revision is the first to treat the 'mutations' and species of *Deinotherium* in ascending geologic order, beginning with the Lower Miocene *Deinotherium cuvieri* of the Sables de l'Orléanais and continuing with the Middle Miocene '*D. bavaricum*,' with the Upper Miocene *D. levius*, and with the Lower Pliocene *D. giganteum*, as follows:

D. cuvieri Burdigalien-Helvétien	*D. bavaricum* (Burdigalien?) Helvétien	*D. levius* Helvétien	*D. giganteum* Helvétien-Pontien
Dinotherium de taille relativement petite, atteignant à peine la moitié de celle du *D. giganteum*.	Taille sensiblement plus grande que celle du *D. Cuvieri*, mais moindre que celle du *D. levius* et surtout du *D. giganteum*.	Taille un peu moindre que celle du *D. giganteum*.	Très grande taille. Dimensions des dents fort variables.
Superior Dentition	Superior Dentition	Superior Dentition	Superior Dentition
(1) Concavity of crests facing posteriorly, M^1 three crested, M^2, M^3 two crested, crowns, with the exception of M^1, less broad than long. M^1, crests gently concave, tritoloph diminishing in breadth, total length 72 mm. M^2, transverse crests incompletely reunited internally, tritoloph narrower than protoloph, length 60 mm. M^3, length 62 mm.	(1) Same characters as in *D. cuvieri*. M^1, same characters as in *D. cuvieri*. M^2, same characters as in *D. cuvieri*, excepting length 72 mm., breadth of protoloph 69 mm., of metaloph 66 mm.	(1) Same observations as in *D. cuvieri*. P^3, narrow internally and somewhat triangular, length 66 mm. P^4, length 70 mm. M^1, marked abbreviation in breadth of tritoloph, other characters more pronounced, length 84 mm. M^2, metaloph narrower than protoloph, length 73 mm. M^3, two lobes more unequal than those of M^2, metaloph smaller, length 77 mm.	(1) Same observations as in *D. cuvieri*. P^3, of subquadrate form, length 80 mm. P^4, length 78 mm. M^1, three transverse crests, i. e., proto-, meta-, and tritoloph, gently concave posteriorly, tritoloph, less strong and less broad, length 95 mm. M^2, two transverse crests, i. e., proto- and metaloph, and crenulated cingulum, length 91 mm. M^3, proto- and metaloph approximately equal, length 91 mm.
Inferior Dentition	Inferior Dentition	Inferior Dentition	Inferior Dentition
(2) Concavity of crests turned forward, molars longer than broad. P_3, protolophid thick and divided into two points, length 43 mm. P_4, length 48 mm. M_1, atrophy and narrowing of tritolophid, length 60 mm. M_2, thickening of cingulum representing the talon, length 59 mm. M_3, talon thick, narrow, triangular, detached from the crown, reflected backward, length 71 mm.	(2) Same observations as in *D. cuvieri*. P_3, protolophid thick and bifid. M_1, tritolophid narrower than the anterior crests, length 73 mm. M_2, talon greatly reduced, length 63 mm. M_3, talon triangular, contracted as in *D. levius*, well detached from the crown, and thrown backward, length 72 mm.	(2) Same observations as in *D. cuvieri*. P_3, anterior lobe compressed into a single triangular point, etc., small posterior talon, length 55 mm. P_4, proto- and metalophid gently concave anteriorly and somewhat united on outer side. Pre- and postcingula little developed, length 70 mm. M_1, reduction of tritolophid in breadth, length 78 mm. M_2, postcingulum smaller, more detached than in M_2 of *D. giganteum*, length 73 mm. M_3, postcingulum narrow, triangular, detached, length 80 mm.	(2) Same observations as in *D. cuvieri*. P_3, anterior lobe simple, narrow, single pointed, length 63 mm. P_4, two transverse crests, i. e., proto- and metalophid, length 70 mm. M_1, three transverse crests, subequal, tritolophid slightly more narrow than metalophid, length 104 mm. M_2, two transverse crests, length 83 mm. M_3, talon nearly as broad as metalophid, crenulated, closely applied to base of metalophid, length 95 mm.
(3) Tusks somewhat short and obtuse.		(3) Tusks shorter, thicker, less sharp than in *D. giganteum*.	(3) Inferior tusks long, pointed at extremity.
		(4) Mental foramen placed more anteriorly below P_3.	(4) Mental foramen at level of P_3 or at interval between P_3 and P_4.



LARTET'S COMPOSITE FIGURE OF THE DECIDUOUS AND PERMANENT DENTITION OF DEINOTHERIUM

Fig. 71. Proportions of *Deinotherium giganteum*, after Lartet, 1859, Pl. XIII, figs. 1–4, reduced to one-third natural size. Lartet remarks (*op. cit.*, pp. 506, 507): "Les pièces en nature qui ont servi de modèle au dessinateur pour recomposer, dans les figures 1 et 2 de cette planche, les séries théoriques de première et de seconde dentition, sont de provenances diverses et probablement aussi d'espèces distinctes; mais on s'est attaché à ramener uniformément toutes ces dents aux proportions du *Dinotherium giganteum*, avec réduction à demi-grandeur de nature." Compare Palmer, 1924, Pl. III, *Deinotherium* sp. (?).

Fig. 1, a, b, c, Superior milk premolars, Dp^2, Dp^3, Dp^4 (upper row).
a′, b′, c′, Inferior milk premolars, Dp_2, Dp_3, Dp_4 (lower row).
Fig. 2, A–E. Permanent dentition, $A = P^3$, $B = P^4$, $C = M^1$, $D = M^2$, $E = M^3$ (upper row).
A′-E′, Permanent dentition, $A' = P_3$, $B' = P_4$, $C' = M_1$, $D' = M_2$, $E' = M_3$ (lower row).
Fig. 3, Fragment of jaw, $c = Dp_4$ being replaced by $B = P_4$; $C = M_1$ [H.F.O.].
Fig. 4, Juvenile jaw showing below A and $B = P_3$ and P_4, $D = M_2$, above a-c = Dp_2, Dp_3, Dp_4, $C = M_1$.

MATERIALS

The above synthetic illustration contains materials from *Lower Miocene* to *Lower Pliocene* horizons, as follows:
Fig. 1, a, b, = *Deinotherium cuvieri*, Lower Miocene of Pontlevoy (Loir-et-Cher).
c, Middle Miocene of the sub-Pyrénées.
a′, Upper Miocene of Simorre (Gers).
b′, Miocene of Gers.
c′, = *Deinotherium bavaricum* (?) ref., Upper Miocene.
Fig. 2, A = *Deinotherium cuvieri* (?), Miocene of Gers.
E, M^3, = *Deinotherium giganteum*, Lower Pliocene of Eppelsheim.
Fig. 3, Fragment of jaw from Ile-en-Dodon (Haute-Garonne), Middle Miocene.
Fig. 4, Jaw, Ile-en-Dodon (Haute-Garonne), Middle Miocene.
For further details, see Lartet's minute description of Plate XIII, 1859, pp. 506–510.

1908. Synonymy and Citations (fide Mayet, 1908)

Lower Miocene *Dinotherium Cuvieri* Kaup, 1831 [1832]	Middle to Upper Miocene *Deinotherium bavaricum* von Meyer, 1831	Upper Miocene to Lower Pliocene *Deinotherium giganteum* Kaup, 1829
1812 Tapir gigantesque Cuvier	1831 *Dinotherium medium* et *secondarium* Kaup	1861 *Dinotherium levius* Jourdan
1825 Tapir gigantesque Cuvier	1832 *Dinotherium bavaricum* von Meyer	
1831 [1832] *Dinotherium Cuvieri* Kaup	1850 *Dinotherium intermedium* de Blainville	
1850 *Dinotherium Cuvieri* de Blainville	1859 *Dinotherium bavaricum* Lartet	
1858 [1859] *Dinotherium Cuvieri* Lartet	1875 *Dinotherium bavaricum* Bachmann	

Deinotherium cuvieri (Observations of Mayet, 1908, pp. 199–206).—Remains very abundant in the Lower Miocene Orléanais, especially at Chevilly, chiefly isolated bones and teeth, type mandible from Chevilly. Entire dentary series represented by remains from Chevilly, Bricy, Boulay, etc., species clearly distinct from the Middle Miocene *D. bavaricum*, the Lower Pliocene *D. giganteum*, or the Upper Miocene *D. levius*.

Dinotherium cuvieri is the sole species found in the Sables de l'Orléanais; certain molars approach those of *D. bavaricum*, a form of much larger size. Characters of *D. cuvieri* notably different from those of *D. giganteum* or *D. levius*, the latter type coming from the Upper Miocene of Grive-St.-Alban, Rhone basin. Thus *D. cuvieri* appears suddenly at the beginning of the formation of the Sables de l'Orléanais, survives into the Faluns du Blésois, and then disappears, to be succeeded by *D. bavaricum*, an ascending mutation of larger size.

Deinotherium bavaricum (Observations by Mayet, 1908, pp. 205, 206).—Von Meyer's type of *Deinotherium bavaricum* from Gmünd, Bavaria, is a Deinothere of medium size closely intermediate between the Lower Miocene *D. cuvieri* and the Lower Pliocene *D. giganteum*. The dental characters of *D. bavaricum* resemble those of *D. cuvieri* more closely than those of *D. giganteum*. From the Sables de l'Orléanais, Chevilly, one molar only is mentioned [?] as representing *D. bavaricum*. Although *D. bavaricum* of the Upper Miocene approaches in size *D. levius* of the Lower Pliocene [Upper Miocene] the dental characters of *D. levius* show much stronger affinity to those of *D. giganteum*. Consequently the larger teeth of the Sables de l'Orléanais probably belong to large examples of *D. cuvieri*.

Ascending Increase in Size [including D. gigantissimum and D. indicum]

Anteroposterior Measurements	P^3	P^4	M^1	M^2	M^3	P_3	P_4	M_1	M_2	M_3	M_{1-3}
Deinotherium gigantissimum									111		348–357e
" *indicum*								100	99		
" *giganteum*	80	78	95	91	91	63	70	104	83	95	282
" *levius*	66	70	84	73	77	55	70	78	73	80	231
" *bavaricum*				72				73	63	72	208
" *cuvieri*			72	60	62	43	48	60	59	71	190

Osborn, 1925: From the above observations of Mayet it becomes perfectly clear that *Deinotherium*, like all other large herbivorous quadrupeds, passed through a series of ascending mutations, witnessed (*a*) in every single character of the superior and inferior grinding teeth, also (*b*) in the steady increase in size. The net anteroposterior diameter of the three lower grinding teeth, obtained by adding the length in millimeters, and including a comparison with *D. giganteum*, is as above.

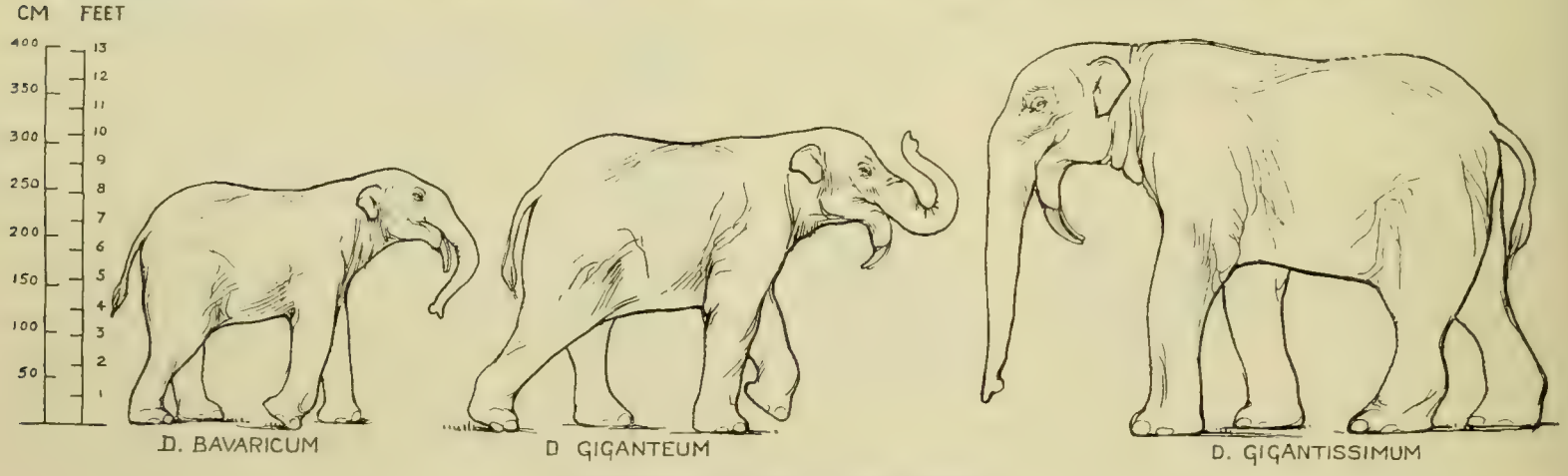
3. RÉSUMÉ OF THE CHIEF GENERIC AND SPECIFIC CHARACTERS

1. Progressive Doubling in Size.—In the above table the measurements given by Mayet of *Deinotherium cuvieri*, *D. bavaricum*, *D. levius*, and *D. giganteum* are amplified by the Falconer (1868, p. 407) and Lydekker (1880, p. 189) measurements of *D. indicum* and by the Stefănescu (1896 [1899], Tab. I, III) measurements of *D. gigantissimum;* they demonstrate a *progressive increase in size,* from the Lower Miocene stage (*D. cuvieri*) to the Pliocene stage (*D. gigantissimum*).

The second inferior molar, M_2, of *D. gigantissimum* (=111 mm.) is about 95% longer than the second inferior molar of *D. cuvieri* (=59 mm.). The inferior molar series, M_{1-3}, of *D. gigantissimum* (=348-357e mm.) is also about 95% greater than the inferior molar series of *D. cuvieri* (=190 mm.).

Consequently, corresponding to the doubling in size of the dental series, we may roughly estimate that the Mid-Pliocene *D. gigantissimum* was an animal about double the size of the Lower Miocene *D. cuvieri.*

These proportions shown in the lower jaws of *Deinotherium cuvieri*, *D. giganteum*, and *D. gigantissimum* (Fig. 69) are also expressed in the diagrammatic restorations (Fig. 72) in which *D. gigantissimum* is represented as nearly double the size of *D. bavaricum*, with *D. giganteum* as intermediate in its skeletal proportions.



Three Specific Stages in Deinotherium

Fig. 72. Proportionate restorations of the year 1930, in profile, of Middle to Upper Miocene and Lower to Middle Pliocene specific stages of *Deinotherium*, with an estimated shoulder height of:

Deinotherium bavaricum	8 ft. 2½ in.
Deinotherium giganteum	9 6
Deinotherium gigantissimum	12

2. Geologic Succession of Species.—The Eurasiatic distribution of the Deinotheres, as carefully worked out for the first time in the accompanying correlation table, displays the *ascending* geologic succession of the species in western and eastern Europe, in southern Asia, and in Africa. When we compare the small *Deinotherium indicum gajense* from the Lower Miocene of India with the *D. pentapotamiæ* [=*D. indicum*] of the Upper Miocene of India, we observe that there is a closely corresponding progressive increase in size of the Deinotheres in all parts of Eurasia where they have been discovered. The approximate geologic parallel between the Deinotheres of western Europe and those of corresponding horizons in India is displayed in Table I (Geologic Correlation) and Table II (Specific Distribution) of the present chapter.

3. Specific Characters in Succession.—As explained in the introductory paragraph of this chapter, "It is not possible for the author to treat the Deinotheres in the same critical or exhaustive manner as the species of proboscideans belonging to other families are treated in the present Memoir; nor is it possible to give the type descriptions or reproductions of the type figures as in other chapters." The reader is referred to the original type

descriptions and figures wherever published, as indicated in the "Order of Discovery and Description of Twenty-six Species of Deinotherium described or named, 1715–1935" (p. 84 above) and in the corresponding bibliographic references below to the works of Kaup, von Meyer, Eichwald, Koch, de Blainville, Falconer, Jourdan, Lydekker, Stefănescu, Pilgrim, Andrews, and Ehik, the only palæontologists to our knowledge who have described type species and specimens of *Deinotherium*. See also Haug, Joleaud, and Leakey in Bibliography.

4. Dentition Relatively Non-progressive.—As compared with other proboscideans both mastodontoid and elephantoid the dentition of the Deinotheres is relatively non-progressive; the fundamental pattern of the grinding teeth was established extremely early in geologic time certainly during the unknown Oligocene stages, because in the Lower Miocene specific stages it is fully established, especially the number of ridges and the character of the crests of the upper and lower true molars, M 1-M 3.

Mayet (1908, pp. 199–206) in his valuable table of specific distinctions (translated in full above) pointed out that the chief progressive characters between *Deinotherium cuvieri*, *D. bavaricum*, *D. levius*, and *D. giganteum* consist in (*a*) progressive increase in size, (*b*) detailed changes of proportion between the anterior and posterior crests, protoloph, metaloph, and tritoloph, (*c*) in the greater or lesser union of the crests externally and internally, (*d*) in the shape and size of the incisive tusks, and (*e*) in the relative position of the mental foramen of the jaw.

	Africa	France, Switzerland	Germany Bavaria	Rumania Russia Bohemia	India
Mid. Pliocene				*D. gigantissimum* Type *D. giganteum* ref.	*D. indicum* Type *D. perimense* Falc. (=*D. indicum*) *D. angustidens* Type
Low. Pliocene		*D. gig. majus* *D. gig. medium* *D. gig. minus*	*D. giganteum* Type (=*D. maximum* T., *D. medium* T., *D. secundarium* T. (?), *D. königii* T.)	*D. uralense* Type	
Up. Miocene		*D. levius* Type *D. intermedium* Type	*D. bavaricum* Type *D. minutum* Type	*D. proavum* Type *D. bavaricum* ref.	*D. pentapotamiæ* Type
Mid. Miocene		*D. giganteum*(?) ref.	*D. bavaricum* ref. *D. secundarium* (?) ref.		*D. sindiense* Type
Low. Miocene	*D. cuvieri* ref. *D. hobleyi* Type	*D. cuvieri* Type			*D. náricum* Type(=*D. indicum gajense*)

Table I.—Approximate Geologic and Geographic Distribution of Twenty-three of the Type Species of Deinotheres, after the Observations Recorded in the Preceding Pages of the Present Chapter IV of this Memoir.
Compare pages 84, 85, 114, and 115.

These specific changes, as pointed out by Mayet, are of minor grade as compared with the profound changes which occur in the grinding teeth of other proboscideans by the addition of crests, by progressive hypsodonty, etc.

The conclusion is therefore justified that *Deinotherium is relatively conservative in the structure of its dentition,* while sharing with all other proboscideans progressive increase in size.

4. CONCLUSIONS AS TO ORIGIN, PHYLOGENY, AND ADAPTIVE RADIATION

Geologic Origin and Range.—*Deinotherium* appears simultaneously in the Lower Miocene of Africa in *D. hobleyi* type and *D. cuvieri* referred, which apparently are in a stage of evolution similar to that of *D. cuvieri* type of the Lower Miocene Sables de l'Orléanais of France, which, in turn, are similar in size to the *D. indicum gajense* type of the Lower Miocene Bugti horizon of Baluchistan. These *three* specific types, which agree approximately in size, require very close examination and comparison before it can be determined which is the most primitive.

The evidence seems to point to an *African origin of Deinotherium,* since there is no indication of ancestral forms of this genus in any Eocene or Oligocene horizon of Eurasia at present known.

Migration.—Well defended by its tusks, well nourished by its precociously lophodont grinding teeth, well transported by its long limbs, *Deinotherium* spread rapidly through northern Africa, southern France, and far eastward into the peninsula of Baluchistan and India. Its traveling companions were the *Trilophodon angustidens libycus* of the Moghara desert, northern Africa, the *Trilophodon angustidens* of the Loire, Sables de l'Orléanais, and the *Trilophodon cooperi* Osb. of Dera Bugti, Baluchistan.

While ranging in the same geographic region, *Deinotherium* was very divergent in habit and local habitat from *Trilophodon,* as indicated by the following adaptive and *generic* contrasts:

Deinotherium

Cranium and jaws abbreviate. Proportions brachycephalic. A very elongate proboscis capable of reaching higher branches of trees also the ground.

Superior tusks early aborted. Inferior tusks rounded, downcurved, recurved, aiding the proboscis in the prehension of branches and leafage.

Grinding teeth sharply crested; Dp4 and M1 trilophodont, P4, M2, and M3 bilophodont; total number of complete transverse crests not exceeding seven; all grinders in use at same time; persistently brachyodont, never hypsodont; probably resembling *Tapirus* in browsing habit on leafage. Superior grinders tending to form ectolophs, like those of primitive tapirs.

Limbs elongate, increasingly elephantoid, raising body well off the ground. Feet reduced to three short functional digits in manus and pes. Dorsolumbar vertebræ and trunk abbreviate.

Trilophodon

Cranium elongate; lower jaws excessively elongate. Limited development of the proboscis, probably a prehensile upper lip, compensated for by great elongation of the lower jaw.

Superior tusks persistently progressive in size, downcurved, aiding the prehensile upper lip in the prehension of food. Inferior tusks horizontal, spatulate, aiding the proboscis in the prehension of food, also employed in the digging and uprooting of plants.

Grinders persistently bunomastodont in pattern; transverse crests increasing to four or five, adapted to the crushing of food, tending to hypsodonty; finally only the posterior grinders, M^3-M_3, in use in advanced age. Browsing and partly grazing habit on low leafage and uprooted plants.

Limbs mastodontoid. Feet tetradactyl to pentadactyl; digits abbreviate. Trunk elongate; low bodied; pelvis broad; mastodontoid in proportions.

The above contrasts of structure and habit prove that from the very first the Deinotherioidea were sharply divergent from the Mastodontoidea. While the geographic range is very similar, as far at least as southern Asia, *Deinotherium* has been found only once in the north (*D. uralense*), whereas *Trilophodon* was a bold northern migrant reaching the 40th parallel of the United States in Middle Miocene time.

Consistent with their divergence of structure is the fact that, while fossil remains of *Deinotherium* are sometimes found in the same horizon with fossil remains of *Trilophodon*, more frequently they are found separate.

Probable Habits and Habitat.—There is little in the limb, foot, trunk, or skeletal structure of *Deinotherium*, now that it is quite fully known from the wonderful Franzensbad specimen (Fig. 64), to support the original theory that this was a fluviatile or water-loving animal which frequented streams and used its lower tusks for the prehension of food from the banks. Yet during warm seasons it doubtless bathed (Fig. 73) in shallow waters, like the modern Indian elephant.

Rather we incline to conclude that it was a forest-living animal, subsisting upon leafage and tree boughs, to which its sharply crested grinding teeth were adapted like those of the tapir and of the tree- or shrub-browsing types of rhinoceroses. The very powerful trunk, indicated in the Eppelsheim cranium (Figs. 57, 58, 59), was eminently adapted to the collecting of tree boughs and leafage, as in the case of the existing African and Indian elephants; the open supranarial space is enormous. The *absence* of large superior tusks, which are seen in all the Mastodontidæ and Elephantidæ, explains the relatively flattened form of the top of the cranium and the forwardly inclined occiput, in wide contrast to the elevated, hypsicephalic and brachycephalic cranium, with vertically placed occiput, for the attachment of large neck muscles to counteract the strain of the greatly elongated tusks.

Consequently *Deinotherium* was neither mastodontoid nor elephantoid in profile but relatively flattened and depressed. The profile aspect of the skull shown in our restorations (Figs. 72, 73) is totally different from that of either *Mastodon* or *Elephas*, while the proboscis was quite as large as that of these animals, and the body height and length of limb approximated that of the largest Proboscidea, as also shown in the restoration (Fig. 70) in comparison with other proboscideans drawn to the same one-hundredth scale.

5. GEOLOGIC DISTRIBUTION OF DEINOTHERIUM. CAUSES OF EXTINCTION

Species of eight mastodont genera, namely, *Trilophodon*, *Anancus*, *Rhynchotherium*, *Zygolophodon*, *Turicius* *Miomastodon*, *Serridentinus*, and *Tetralophodon*, were contemporaneous with *Deinotherium*, as shown in Table II below (Geologic and Geographic Distribution of the Types of the Superfamily Deinotherioidea, as compared with the Types of the Contemporary Mastodontoidea and Stegodontoidea[1]).

The student should turn immediately to Table II below, in which the geologic and geographic distribution of most of the types of these deinotherioid and mastodontoid species are carefully set forth, also to the geographic distribution charts showing exactly where these types were found; by this means the zoologic and geographic environment of the Deinotheres is clearly brought out.

It will be observed that while the Deinotheres belong chiefly in competition with animals of the Mastodontoid period, they are now known to survive into the period of Elephantoid distribution.

Aided by different local adaptive radiation, probably in the forested regions of southern Eurasia, the Deinotheres with their brachyodont, tapiroid grinding teeth were able to compete with the bunomastodont genera, *Trilophodon*, *Tetralophodon*, and *Anancus*. It is probable that they enjoyed an entirely different local geographic range from the purely zygolophodont genera, *Zygolophodon* and *Turicius*.

It is not an unreasonable *hypothesis of extinction* that the brachyodont Deinotheres were unable to compete with the incoming Stegodonts with their very numerous transverse crests and tendency to hypsodonty. At all events, the climax of the series (*Deinotherium gigantissimum*) in southern Eurasia becomes extinct in Middle Pliocene time, just prior to the appearance of numerous species of *Stegodon*. In Africa the Deinotheres survived.

This hypothesis of the failure of the brachyodont, tapiroid types of Deinothere grinding teeth to compete with the subhypsodont and hypsodont types of the rising superfamily Elephantoidea[1] will afford a parallel in the Proboscidea of what we observe in the ungulates all over the world, because in Pliocene time *hypsodont* ungulates began to prevail over the *brachyodont* ungulates, as first observed in Kowalewsky's great Memoir of 1873.

[1]See footnote 2 on page 22.

	Mastodonts and Stegodonts of Europe	Deinotheres of Europe	Deinotheres, Mastodonts, and Stegodonts of Asia and Africa
Pleistocene			
Olduvai, Africa			*Deinotherium hopwoodi* Type
Étage Plaisancien, Pliocène Infér. (= Étage Levantin, Austria-Hungary) = Middle Pliocene of Present Memoir			
Schlesien	*Stegolophodon sublatidens* Type (Hungary)		
Batta-Érd, Rákoskeresztúr, Szentlörincz, Ajnácskö	*Pliomastodon americanus praetypica* Cotypes (Hungary) Upper (?) Pliocene		
Couches saumâtres à congéries; Casino (Tusc.) Lg.[1] Rumania(?)			
Găiceana, Rumania		*Deinotherium gigantissimum* Type	
Mânzaţî Valley, Rumania		*Deinotherium gigantissimum* Ref.	
India			*Tetralophodon punjabiensis* Type (Dhok Pathan horizon) *Tetralophodon* (*Lydekkeria*) *falconeri* Type (Dhok Pathan horizon) *Synconolophus dhokpathanensis* Type (Dhok Pathan horizon) *Synconolophus hasnoti* Type (Dhok Pathan horizon) *Synconolophus corrugatus* Type (Dhok Pathan horizon)
Perim Island			*Anancus perimensis* Type (Perim Island) *Stegolophodon cautleyi* Type (Perim Island) *Deinotherium indicum* Type (Perim Island) (*D. Perimense* Falc. = *D. indicum*) (Perim Island) *Deinotherium angustidens* Type (Perim Island)
Étage Messinien (Pontien), Pliocène Infér.			
Eppelsheim (Germany); Pikermi (Greece); Samos; Maragha (Persia); = Mt. Léberon (Vaucluse); Cucuron; Puy Courny; = Belvedereschotter (Austr.) Fl.[2]; Baltávar (Hung.); = Concud, 'Alcoi (Spain); Upper Deinotherium Sands (Augsburg)	*Trilophodon* (*Choer.*) *pentelicus* Type *Tetralophodon longirostris* Type *Tetralophodon grandincisivus* Ref. *Tetralophodon dubius* Type *Tetralophodon grandis* Type *Turicius atticus* Type *Miomastodon tapiroides americanus* Type (Hungary)	*Deinotherium giganteum* Type *Deinotherium maximum* Type *Deinotherium medium* Type *Deinotherium secundarium*(?) Type *Deinotherium königii* Type *Deinotherium gig. majus* *Deinotherium gig. medium* *Deinotherium gig. minus*	*Tetralophodon grandincisivus* Type (Maragha, Persia)
Ural (Russia)		*Deinotherium uralense* Type	
India			*Stegodon bombifrons* Type (Siwaliks, India)
Irrawaddy River, Burma			*Stegolophodon latidens* Type (Irrawaddy River, Burma) *Stegodon elephantoides* (= *cliftii*) Type (Irrawaddy River, Burma) *Stegodon elephantoides* Type (Irrawaddy River, Burma)

Étage Tortonien, Miocène Supér.			
Grive-St.-Alban (Isère) Fl.; Molasse de l'Anjou; St. Jean de Bournay; Cabrières; = Steinheim (Würt.); Günzburg, Ries (Nordlingen), Georgensgemünd, Gmünd (Bav.); Mösskirch (Germany); Obere Süsswasser Molasse, Œningen, Elgg, Käpfnach, Lower Deinotherium Sands; = Monte Bamboli (Tusc.) Lg.		*Deinotherium levius* Type *Deinotherium intermedium*(?) Type *Deinotherium bavaricum* Type *Deinotherium minutum* Type	
	Turicius turicensis Type		
Podolia (Russia)		*Deinotherium proavum* (?) Type	
Attock or Sind; India			*Deinotherium pentapotamiæ* Type (Attock or Sind)
China			*Tetralophodon (Lydekkeria) sinensis* Type (Yun-nan, China) *Stegodon sinensis* Type (China)
Étage Helvétien, Miocène moyen			
Calcaire de Sansan (Gers) L. infèr., Calc. de Simorre supér. St. Gaudens, Ile-en-Dodon (Haute-Garonne); = Steiermark braunkohle, Eibiswald, Wies, Göriach, Voitsberg; Franzensbad (Bohemia)	*Trilophodon angustidens* Type *Turicius turicensis simorrensis* Type *Zygolophodon pyrenaicus* Type *Serridentinus subtapiroideus* Type	*Deinotherium secundarium* (?) (ref. Lartet) *Deinotherium bavaricum* ref. (Franzensbad, Boh.)	*Serridentinus mongoliensis* Type (Loh, Mongolia)
Moghara (Africa)			*Rhynchotherium spenceri* Type (Moghara)
India			*Deinotherium sindiense* Type (Sind, India) *Trilophodon pandionis* Type (Larkana District, Sind, Ind.) *Trilophodon angustidens palæindicus* Type (near Kamlial, Punjab)
Étage Burdigalien, Miocène Infér.			
Sables de l'Orléanais (Loire); Calcaire de Montabusard; Molasse du Royans; = Grauen Süsswasser Molasse (Lausanne); Engelhalde; Rappenfluh; Ulm (Eselsberg, Eckingen); = Eggenburg, M.; Brûttelen (Switz.); Algeria (N. Africa); Moghara (N. Egypt); Karungu (near Victoria Nyanza)	*Trilophodon pontileviensis* Type *Turicius tapiroides* Type *Zygolophodon pyrenaicus aurelianensis* Type *Miomastodon depereti* sp. nov. (Chevilly)	*Deinotherium cuvieri* Type (Comminge, Carlat-le-Comte, Chevilly)	
		Deinotherium hungaricum Type (Hungary)	*Trilophodon angustidens libycus* Type (Moghara) *Deinotherium cuvieri* ref. (Moghara) *Deinotherium hobleyi* Type (Victoria Nyanza)
Japan			*Serridentinus annectens* (Japan)
Dera Bugti (Bugti Beds), Bugti Hills, Baluchistan			*Deinotherium náricum* Type = *D. indicum gajense* (Baluchistan) *Trilophodon cooperi* Type

TABLE II.—GEOLOGIC AND GEOGRAPHIC DISTRIBUTION OF THE TYPES OF THE SUPERFAMILY DEINOTHERIOIDEA, AS COMPARED WITH THE TYPES OF THE CONTEMPORARY MASTODONTOIDEA AND STEGODONTOIDEA.

[1] Lg. = Lignites
[2] Fl. = Fluviatile

Fig. 73. Restoration of Deinotherium gigantissimum Stefănescu of the Mânzaţi Valley, Rumania
By Margret Flinsch (1933), under the direction of Henry Fairfield Osborn

The gigantic Deinotheres represented in this drawing are based on the dimensions of the type lower jaw and five grinding teeth described in the year 1899 by Gregoriŭ Stefănescu of the University of Bucharest, discovered in the Mânzaţi Valley, central Rumania. As stated on pages 95 to 98, the skeletal material described and figured is not from the type locality; the tibia and pes are figured on page 97 (Fig. 62). The restoration scene is in the Mânzaţi Valley during the Middle Pliocene period when these animals reached their climax in size, to which the specific name *gigantissimum* appropriately refers. Warm midsummer season.

The limb proportions of the skeleton are certainly mastodontoid rather than elephantoid; they are based on proportions of the *Deinotherium bavaricum* of Franzensbad (Fig. 63, p. 99). The three different feeding poses and attitudes represent a theoretic interpretation of the adaptations of the lower tusks as well as of the proboscis in these remarkable animals. The tusks were used along river banks for uprooting function; also in combat between the males and in warding off enemies, while the proboscis was used in the conventional proboscidean way in reaching for and drawing down foliage.

APPENDIX OF CHAPTER IV

Deinotherium hungaricum Éhik, 1930

Figure 74

Type: Kotyháza (Dep. Nógrád), Hungary. Lower Miocene (?), Burdigalian age. Paratype: Királd (Dep. Borsod), Hungary.

Prodinotherium hungaricum Éhik, 1930. "Prodinotherium hungaricum N.G., N.Sp." with an Appendix by T. Szalai "On the Geological Occurrence of *Prodinotherium hungaricum* Éhik," Geol. Hungarica, Ser. Palaeont., Fasc. 6, pp. 3–21. Type.—Lower mandible containing l.P_4–M_3, r.P_4, M_2, M_3; also fragment of scapula and limb fragments (humerus, ulna, radius, carpals, and portions of metacarpals). Locality and Horizon.—Kotyháza (Dep. Nógrád), Hungary. Embedded in a blue clay belonging to the Aquitanian (?) period. Paratype.—Molar and tusk fragments, from Királd (Dep. Borsod), Hungary. Type Figure.—*Op. cit.*, Pl. I, figs. 1–3, Pls. II, III, and IV. Paratype Figures.—*Op. cit.*, Pl. I, figs. 4–7.

Specific Characters.—(Cf. Éhik, p. 14) *Third premolar.* . . . "in the case of *D. Cuvieri* and *D. Hobleyi* the hypoconid and the entoconid [of Pm_3] are connected by a posterior cingulum, while with the specimen of Királd the entoconid of pm3 lies inside of the cingulum and is thus in no connection with it. This peculiar formation of the pm3 distinguishes the Hungarian specimen from all *Dinotheria* hitherto described, so as from the larger species too." *Mental foramen.* . . . "in the case of the Hungarian animal it [posterior mental foramen] is to be found in the vertical separating the pm3 from the pm4. The place of the anterior mental foramen is unknown with *D. Hobleyi;* in the case of *D. Cuvieri* it falls below the middle of pm3; in the Hungarian specimen it is situated below the anterior edge of the pm3. In consideration of all these circumstances I give a new name viz: *D. hungaricum* to the specimen found at Kotyháza and Királd. . . . From the systematic point of view the mesatipody is a much more primitive character, than the systematically highly progressed dolichopody. This very interesting and important difference in the structure of the foot induces me to class the *D. hungaricum* into a new genus, under the genetic name of *Prodinotherium.*"

"The *Prodinotherium hungaricum* must be by all means one of the eldest *Dinotheria* hitherto known from an exactly determined geological age."

Geology.—(Szalai, *op. cit.*, p. 19): "On both find places of *Prodinotherium hungaricum* Éhik, namely at Kotyháza, in the

neighborhood of Salgótarján, and at Királd not very far from the former locality, the bed layers of the coal-measures are generally formed by a tough clay. Its material is sometimes of a swelling kind, sometimes of a sandy one, and its colour is bluish gray if wet, and greenish gray when dry. Embedded vegetal remains are to be found rather abundantly in this clay, among which *Calamus* . . . and *Cinnamomum* . . . are the most frequent, whilst the Vertebrate fauna is represented by *Mastodon angustidens* Cuv., . . . *Aceratherium tetradactylum* Lart., . . . *Prodinotherium hungaricum* Éhik, . . . *Testudo Fejérváryi* n. sp. . . . and some *Trionyx* . . . remains."

Osborn, 1932: The presence of '*Mastodon*' *angustidens* indicates that these coal measures are of Burdigalian (Lower Miocene) age rather than of Aquitanian (Upper Oligocene) age; in fact, Szalai remarks (*op. cit.*, p. 21) "The *Prodinotherium* remains described by Éhik are especially important from the stratigraphical point of view: for they are the only Dinotherian fossils which undoubtedly belong to the transition beds connecting the Upper Oligocene with the Lower Miocene, precisely this set of strata representing the Aquitanian. The biohistorical importance of such statement lies, moreover, in the fact that no Dinotherian remains are known, up to now, from strata older than those belonging to the Aquitanian."

TYPE OF DEINOTHERIUM HUNGARICUM

Fig. 74. Type mandible of *Prodinotherium hungaricum* Éhik, 1930, Pl. II, figs. 1 and 2, in oblique (upper) and right lateral (lower) aspects. About one-eighth natural size.

In the opinion of the present author, the characters of the paratype premolar of Királd (Pl. I, fig. 7) serve to distinguish a new *specific* rather than a new *generic* stage. Consequently we are inclined to consider *Prodinotherium* as a synonym of *Deinotherium* until further evidence is adduced to the contrary.

DEINOTHERES RECENTLY DISCOVERED IN AFRICA[1]

Deinotherium hopwoodi sp. nov.

Figure 68a

From Olduvai, near the southeast shore of Lake Victoria, Tanganyika Territory, Africa. Middle Pleistocene.

The most surprising discovery of recent years is the survival of *Deinotherium* into the Middle Pleistocene of central Africa. The beautifully preserved type molars (Fig. 68a, p. 104) were regarded by Hopwood (letter, Feb. 5, 1934) as referable to the Lower Pliocene *D. giganteum* stage, from which they are quite distinct. For reasons given below they are made the type of *Deinotherium hopwoodi*.

These grinders (Fig. 68a), an l.M_3 (Brit. Mus. M. 14119, cast Amer. Mus. 27005), ap. 97 mm., tr. 87 mm., and an l.M^3 (Brit. Mus. M. 14118, cast Amer. Mus. 27006), ap. 91 mm., tr. 96 mm., compare in size with those of the Lower Pliocene *Deinotherium giganteum* Kaup (l.M_3, ap. 95 mm., tr. 83 mm.; l.M^3, ap. 91 mm., tr. 93 mm.), while inferior to those of the Middle Pliocene *D. gigantissimum* (l.M_3, ap. 114 mm., tr.?; l.M^3, ap. 114 mm., tr. 117 mm.).

In the same pit with the above type grinders were found three other molars,[2] namely, third inferior premolar, l.P_3, ap. 81 mm., tr. 63 mm., index 78, fourth superior premolar, r.P^4, ap. 89 mm., tr. 90 mm., index 101, and finally a second superior molar, l.M^2, ap. 101 mm., tr. 100 mm., index 99.

The teeth found (Fig. 56+) in the Lower Pleistocene of Abyssinia (Haug, 1911; Joleaud, 1928), referred to *D. giganteum*, probably belong to this species.

The type locality (Fig. 56, 25), Olduvai, Tanganyika Territory, Lat. 2° 58′ S, Long. 3° 24′ E, is a most inaccessible semi-desert place, a day's march from the nearest good water supply. Hopwood (letter, Feb. 5, 1934) reports that the type teeth were found in the lowest of the four horizons referable to the Middle Pleistocene. They were mixed up with a partial skeleton of a very young *Elephas antiquus recki*, and on the other side of the dry water-course were found other remains of the same elephant at the same level; also that teeth belonging to *Deinotherium* have been found in the Lower Pleistocene of Abyssinia (Haug, 1911, Joleaud, 1928), as well as in the Pleistocene of Kanam, Kenya Colony.

CONELETS.—Beautifully preserved and fitting closely in apposition, as if belonging to a single individual, these type grinders display the conelets of which the crests were formed, namely: protolophid of l.M_3 (16 conelets), metalophid of l.M_3 (14e conelets); protoloph of l.M^3 (14 conelets), metaloph of l.M^3 (12 conelets). On this character, which to Osborn's knowledge has not been mentioned before, also on the superior size, the species *Deinotherium hopwoodi* has been based by Osborn, in recognition of Doctor Hopwood's never-failing coöperation with the author in the preparation of this Memoir, in addition to his distinguished work in the African field.

[1]See also Leakey's discovery of *Deinotherium* sp.?, of Pleistocene age, in central Africa, Kavirondo Gulf (pp. 85 and 105 of the present Memoir).

[2]The originals of these referred molars are in the British Museum, namely, Brit. Mus. M.14116, M.14115, and M.14117, respectively.

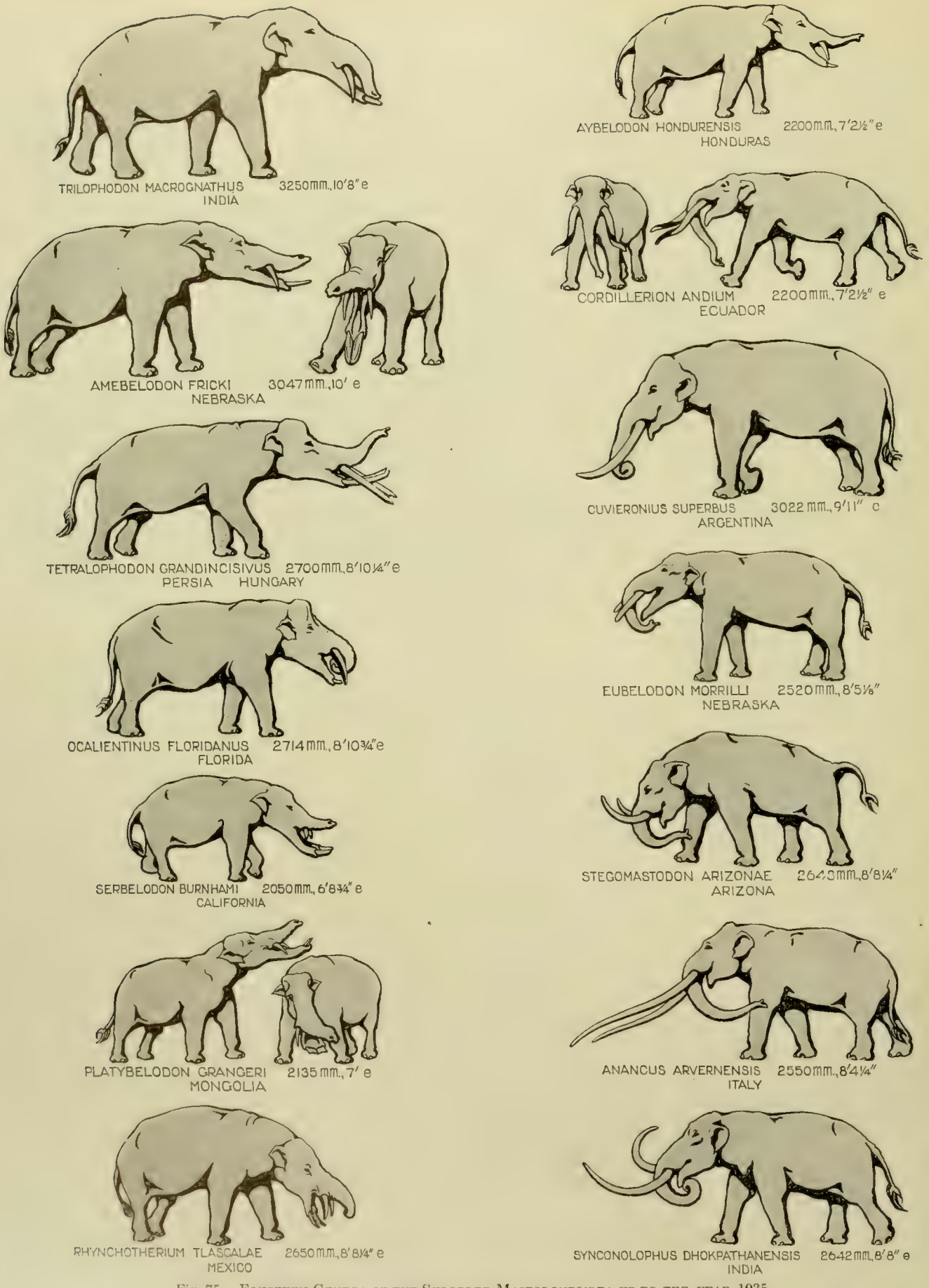


Fig. 75. Fourteen Genera of the Suborder Mastodontoidea up to the year 1935
Restorations to a one-hundredth scale by Margret Flinsch, under the direction of Henry Fairfield Osborn

Chapter V

HISTORY OF THE CLASSIFICATION OF THE MASTODONTOIDEA, FAMILIES AND SUBFAMILIES, 1705-1927

Gradual separation of the 'species'[1] composing the Cuvierian genus Mastodon into two distinct families, Mastodontidæ and Bunomastodontidæ, and into seven distinct subfamily phyla, Mastodontinæ, Zygolophodontinæ, Longirostrinæ, Serridentinæ, Rhynchorostrinæ, Notorostrinæ, and Brevirostrinæ.

1. Cuvier's five classic 'species' of *Mastodon* represent four [five] subfamilies.
2. Cuvier's original conception of his genus '*Mastodonte*,' 1806. Types and definitions of five species.
3. The Zygolophodontinæ: Separation by Schinz and Vacek from the Longirostrinæ.
4. The Brevirostrinæ: Separation by Lortet and Chantre from the Longirostrinæ and Zygolophodontinæ.
5. The Zygolophodontinæ (=*Mastodon borsoni*): Final separation (Russia, 1894) from the Mastodontinæ (=*Mastodon americanus*).
6. Separation of species of '*Mastodon*' and '*Elephas*' described in America (1792–1874).
7. Osborn's classification (1927) of the superfamily Mastodontoidea.
8. Cuvier and the Revolutions of the Globe.

(January, 1934) Many discoveries since 1927 have altered or modified the statements made in this chapter. During the seven years (1927–1934) four additional subfamilies were discovered or defined, namely, the Amebelodontinæ, the Platybelodontinæ, the Tetralophodontinæ, and the Humboldtinæ subfam. nov.; also the families Serridentidæ fam. nov. and Humboldtidæ fam. nov. (1935) Three new subfamilies are added, namely, Palæomastodontinæ, Gnathabelodontinæ, and Stegolophodontinæ. The final classification, therefore, will be found in the Appendix at the close of the present Volume.

Cuvier, 1806.—Cuvier, the founder of vertebrate palæontology, fell heir to all the collections in the Muséum d'Histoire Naturelle of Paris and was the first to distinguish specifically the true mastodont form of molar without trefoils from the bunomastodont form of molar with trefoils. Cuvier was more impressed with the resemblances between these two forms of molars than with the differences; consequently he included both forms within his single genus '*Mastodonte*' (=*Mastodon*), which he divided into five classic species that became the starting point of all future descriptions and which survive to the present day; these species also are subdivisible according to modern discovery, as below; he did not adopt the binomial system of Linnæus until 1817.

Osborn, 1927.—We now know that these five Cuvierian 'species' belong in two[1] distinct families, namely, the Mastodontidæ and the Bunomastodontidæ, and in four[1] distinct subfamilies, namely, the Mastodontinæ (including *Mastodon giganteum* Cuv.), the Zygolophodontinæ (including *M. tapiroides* Cuv.), the Longirostrinæ (including *M. angustidens* Cuv.), and the Notorostrinæ (including *M. andium* Cuv. and *M. humboldtii*[2] Cuv.).

It has taken more than a century of research, concluding with the present Memoir, to discover that *five entirely different lines of descent* actually separated these five Cuvierian 'species' in geologic time and divided them up among five generic and four[1] subfamily phyla, as follows:

Species of Cuvier	Genera, Subfamilies, Families, and Superfamilies of the Present Memoir			
Mastodon giganteum Cuv.	*Mastodon americanus*	Subfam. Mastodontinæ	Fam. Mastodontidæ	Superfam. Mastodontoidea
Mastodon angustidens Cuv.	*Trilophodon angustidens*	" Longirostrinæ	" Bunomastodontidæ	" "
Mastodon tapiroides Cuv.	*Turicius tapiroides*	" Zygolophodontinæ	" Mastodontidæ	" "
Mastodon andium Cuv.	*Cordillerion andium*	" Notorostrinæ	" Bunomastodontidæ	" "
Mastodon humboldtii Cuv.	*Cuvieronius humboldtii*[2]	" Notorostrinæ	" Bunomastodontidæ	" "

[1](Osborn, 1934) These Cuvierian 'species' now belong in three families and five subfamilies through the addition of the Humboldtidæ fam. nov. and the Humboldtinæ subfam. nov.

[2](Osborn, 1934) now referred to the Humboldtinæ subfam. nov., of the Humboldtidæ fam. nov.

1. CUVIER'S FIVE CLASSIC 'SPECIES' OF MASTODON REPRESENT FOUR[1] SUBFAMILIES

It was characteristic of Cuvier that he was very reluctant to admit the existence of more than one genus of either mastodonts or elephants, namely, *Mastodon* and *Elephas;* or to admit the existence of more kinds of fossil proboscideans than he himself had seen or described. This reluctant spirit has been manifested by many of his followers down to the present time.

Subfamily Mastodontinæ Osborn, 1910, of the Present Memoir

See Chapter VI for detailed descriptions

Cuvier was not in the habit of clearly designating his type specimens; consequently we select for the types of the Mastodon the teeth from the Ohio River first discovered, described, and figured as the types of *Mastodonte de l'Ohio* [=*Mastodon americanus* Kerr—Fig. 76].

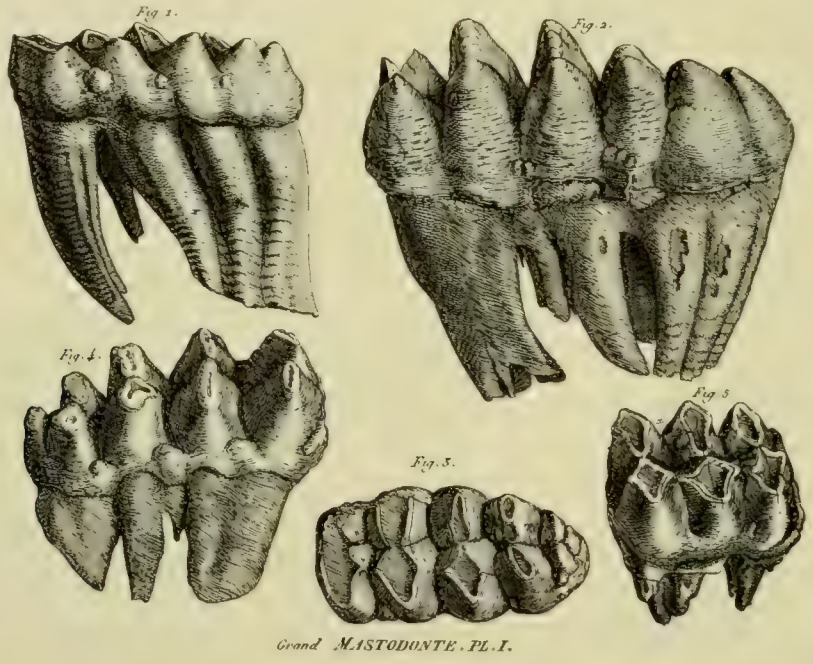


Fig. 76. Cuvier's types of *Mastodonte de l'Ohio* or *Le Grand Mastodonte*, 1806.2, Pl. 49 [1]. [=*Mastodon americanus* Kerr of the present Memoir.] See figure 112.

Subfamily Zygolophodontinæ Osborn, 1923, of the Present Memoir

See Chapter VII for detailed descriptions

Petit Mastodonte (=*Mastodon* [*Turicius*] *tapiroides* Cuvier, 1806—see Figs. 77, 160, and 161), from the Lower Miocene of the Calcaire de Montabusard, with lophoid crests, *without* trefoils, has become the prototype of the zygolophodont phylum of the Miocene, including *M. turicensis* Schinz, *M. affinis* Jourdan, *M. borsoni* Hays, as shown in the conspectus of Mayet (1909, p. 45, B). This phylum is treated by Schlesinger (1917, pp. 146–162) under the heading "Mastodon (Zygolophodon) tapiroides Cuvier." *Mastodon tapiroides* Cuv. is treated by Osborn in the present Memoir as *Turicius tapiroides.* The reasons for the separation by Osborn in 1926 (Osborn, 1926.706) of the genus *Turicius* from the genus *Zygolophodon* are given in Chapter VII, pp. 198–202, of the present Memoir. See also Pls. II and III, between pp. 134–135.

Fig. 77. Cuvier's type of *Petit mastodonte*, 1806, from Montabusard=*Turicius tapiroides.*

[1](Osborn, 1934) Five subfamilies (see footnote on page 119).

Subfamily Longirostrinæ Osborn, 1918, of the Present Memoir

See Chapter VIII for detailed description (p. 252) and new figure (Fig. 299) of Cuvier's type

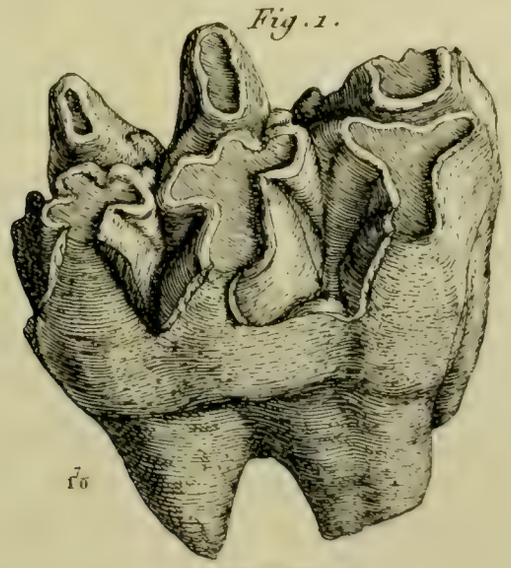
Cuvier's type (Figs. 78, 190, 299) from Simorre (*Mastodonte à dents étroites* = *Mastodon* [*Trilophodon*] *angustidens* Cuv.), with narrow molars and single trefoils, appears in the modern literature (e. g., Schlesinger, 1917) as a collective species of all the Miocene Longirostrines of Europe; it includes, as synonyms or trinomials, *Mastodon minutus* Cuv., 1824, of Saxony, *M. simorrense* Lartet, 1851, *M. gaujaci* Lartet, 1851, and *M. cuvieri* Pomel, 1854 [1848], as revised and listed by Mayet (Mam. Fos., 1909, p. 44, A). This phylum is treated most fully by Schlesinger (Denk. Naturhist. Hofmus., I, 1917, pp. 5–63), under the heading "Mastodon (Bunolophodon) angustidens Cuv." A new figure of the type has been prepared (see Chap. VIII, Fig. 299) from a cast presented to the American Museum in 1927 by the British Museum. This cast was one of two sent to Gideon Mantell by Cuvier, both of which were acquired by the British Museum with the purchase of the Mantell Collection about the middle of the last century.

Fig. 78. Cuvier's type of *Mastodonte à dents étroites*, 1806 [=*Trilophodon angustidens* of the present Memoir]. See new figure from cast (Fig. 299) in Chapter VIII.

Subfamily Notorostrinæ Osborn, 1921, [and Humboldtinæ subfam. nov.] of the Present Memoir

See Chapter XII for detailed descriptions

Regarding Cuvier's South American types: (1) It is important to note that the type (Fig. 79) of *Mastodonte des Cordilières* [=*Cordillerion andium* of the present Memoir], distinguished by single trefoils, is from near a



Notorostrinæ

Fig. 79. Cuvier's type of *Mastodonte des Cordilières*, 1806 [=*Cordillerion andium* of the present Memoir].

Humboldtinæ

Fig. 80. Cuvier's type of *Mastodonte humboldien*, 1806 [=*Cuvieronius humboldtii* of the present Memoir].

volcano in the vicinity of Quito, Ecuador; (2) the type (Fig. 80) of *M. humboldien*, distinguished by double trefoils (now referred to a distinct genus, *Cuvieronius*, in honor of Cuvier), is from near Concepcion, Chile. Further characterization of these South American species is given in the phylogenetic section below (Chap. XII).

2. CUVIER'S ORIGINAL CONCEPTION OF HIS GENUS 'MASTODONTE,' 1806

(January, 1935) Written by Osborn in the year 1927, Sections 4-7 are now somewhat out of date (see Appendix at close of the present Volume).

Cuvier conceived his genus *Mastodonte* as embracing animals possessing the five different types of grinding teeth shown in his five type figures above; this is a 'collective' genus in the same sense that most of the original genera of Linnæus were collective, that is, embracing several 'species' and 'genera' in the modern usage of these terms.

According to all authors, Cuvier's first references to his genus *Mastodonte* are in the Annales du Muséum d'Histoire Naturelle of 1806 (1806.2, p. 270). In the same year, in a subsequent paper, he observed (1806.3, p. 413): "Ainsi le genre se trouvera composé de cinq espèces, toutes également inconnues aujourd'hui sur la terre."

His original descriptions, references, and figures of these five species are as follows (Cuvier, 1806.2, pp. 270, 293; 1806.3, p. 412):

	Original and Present Reference	
"Je nommerai donc la grande espèce [*op. cit.*, pp. 412, 413], *Mastodonte de l'Ohio*;	[*Mastodon giganteum* Cuv. = *Mastodon americanus*]	Ann. Mus., VIII, p. 293, Pl. 49 [I], Figs. 1-5; also Pls. 50 [II] to 56 [VIII], *fide* de Blainville. (Type confirmed by de Blainville in his revision of 1839-64, p. 245.)
Celle de *Simorre* et d'ailleurs, *Mastodonte à dents étroites*;	[*Mastodon angustidens* Cuv. = *Trilophodon angustidens*]	Ann. Mus., VIII, p. 405, Pl. 66 [I], Fig. 4; Pl. 67 [II], Figs. 2, 4, 6, 11, and 13 (*fide* de Blainville). (Type confirmed by de Blainville in his revision of 1839–64, p. 246.)
Celle des petites dents, *Petit mastodonte*;[1] [de Montabusard]	[*Mastodon tapiroides* Cuv. = *Turicius tapiroides*]	Ann. Mus., VIII, p. 411, Pl. 68 [III], Fig. 6. (Type confirmed by de Blainville in his revision of 1839–64, p. 251.)
[de Saxe]	[*Mastodon minutus aut. minor* = (?) *Trilophodon angustidens minutus*]	Ann. Mus., VIII, p. 411, Pl. 67 [II], Fig. 11. (Type confirmed by de Blainville in his revision of 1839–64, p. 250.)
La grande à dents carrées, *Mastodonte des Cordilières* [près du volcan d'Imbaburra, Quito, Ecuador]	[*Mastodon andium* Cuv., 1824,[2] = *Mastodon cordillerarum* Desm., 1820-1822, = *Cordillerion andium*]	Ann. Mus., VIII, pp. 411, 413, Pl. 67 [II], Fig. 1. (Type confirmed by de Blainville in his revision of 1839–64, p. 249.)
Et la plus petite, *Mastodonte humboldien* [de la Conception du Chili]"	[*Mastodon humboldtii* Cuvier in Desmarest, 1818, p. 447 = *Cuvieronius humboldtii*]	Ann. Mus., VIII, pp. 412, 413, Pl. 67 [II], Fig. 5. (Type confirmed by de Blainville in his revision of 1839–64, p. 249.)

Le Grand Mastodonte Cuv. (Cuvier, 1806.2, Ann. Mus., VIII, pp. 270, 293) or *Mastodonte de l'Ohio* Cuv. (Cuvier, 1806.3, p. 412) = *Mastodon giganteum* Cuv., 1817 ("Le Règne Animal," p. 233). Type.—Cuvier, 1806.2, Pl. 49 [I], figs. 1–5; confirmed by de Blainville (1839–1864, p. 245). Type Description.—Cuvier, 1806.2, pp. 270, 273, 293; 1806.3, p. 412.

= *Mastodon americanus* of the present Memoir.

"*Mastodonte à dents étroites*" Cuv., 1806 (Ann. Mus., VIII, 1806, pp. 405, 412) = *Mastodon angustidens* Cuv., 1817 ("Le Règne Animal," p. 233). Type.—Cuvier, 1806.3, Pl. 66 [I], fig. 4; confirmed by de Blainville

[1] In 1806 Cuvier regarded the little teeth of Montabusard (= *M. tapiroïde* Cuv., 1821) and of Saxony (= *M. minutus* Cuv., 1824) as belonging to the same species, namely, *Petit mastodonte*. See Cuvier, 1806.3, p. 411: "La dent de *Montabusard*, pl. III, fig. 6, correspond si bien à celle de Saxe pour sa largeur, que je ne doute pas que ce ne soit un germe de l'une des postérieures de la même espèce, cassé en avant."

[2] The specific names *M. andium* Cuv. and *M. cordillerarum* Desm. refer to the same type description (Cuvier, 1806.3) of the *Mastodonte des Cordilières*. We may follow de Blainville and Falconer in choosing the specific name *andium*.

("Ostéographie des Mammifères," 1839–1864, p. 246). TYPE DESCRIPTION.—(Cuvier, 1806.3, p. 405): "Je commence par une dent de Simorre, pl. I, fig. 4." (Detailed description and measurements of this tooth and comparison with other teeth from Simorre also of *M. giganteum*, pp. 401 to 420).

= *Trilophodon angustidens* of the present Memoir.

Petit mastodonte, celle des petites dents, Cuvier, 1806.3, p. 413 = *Mastodonte tapiroïde* Cuv., 1821 (Cuvier, 1821–1824, Vol. I, p. 268), subsequently written *Mastodon tapiroides* (see Desmarest, 1820–1822, p. 386, also Cuvier, 1821–1824, Vol. V, Pt. 2, p. 527). TYPE.—Cuvier, 1806.3, Pl. 68 [III], fig. 6; confirmed by de Blainville (1839–1864, p. 251). TYPE LOCALITY.—Calcaire de Montabusard. (See below *Petit mastodonte* = *Mastodon minutus*.) TYPE DESCRIPTION.—(Cuvier, 1806.3, p. 411): "La dent de *Montabusard*, pl. III, fig. 6, correspond si bien à celle de Saxe pour sa largeur, que je ne doute pas que ce ne soit un germe de l'une des postérieures de la même espèce, cassé en avant."

(de Montabusard, L. Miocene) = *Turicius tapiroides* of the present Memoir.

Petit mastodonte, celle des petites dents, Cuvier, 1806.3, p. 413 = *Mastodon minutus* Cuv., 1824 (Cuvier, 1821–1824, Vol. V, Pt. 2, p. 527). TYPE.—Cuvier, 1806.3, Pl. 67 [II], fig. 11; confirmed by de Blainville (1839–1864, p. 250). TYPE LOCALITY.—Saxony. (See above *Petit mastodonte* = *Mastodon tapiroides*.) TYPE DESCRIPTION.—(Cuvier, 1806.3, p. 411): "Telle est la dent de Saxe, envoyée autrefois par le professeur de Gottingue, *Hugo*, à Bernard *de Jussieu*, et que l'illustre neveu de celui-ci a bien voulu me communiquer, Pl. III [II, 67], fig. 11, entièrement semblable en figure et en proportions à celle de la fig. 4, pl. I. Elle est exactement d'un tiers moindre."

(de Saxe, Miocene) = *Trilophodon angustidens minutus* of the present Memoir.

Mastodonte des Cordilières, la grande à dents carrées, Cuvier, 1806.3, p. 413 = *Mastodon Andium* Cuv., 1824 (Cuvier, 1821–1824, Vol. V, Pt. 2, p. 527), and *M. cordillerarum* Desmarest, 1820–1822, p. 385. TYPE.—Cuvier, 1806.3, Pl. 67 [II], fig. 1; confirmed by de Blainville (1839–1864, p. 249). TYPE LOCALITY.—Volcano near Quito, Ecuador. TYPE DESCRIPTION.—(Cuvier, 1806.3, p. 411): "Les plus grandes ont les mêmes dimensions que leurs correspondantes de *l'Ohio*. M. *de Humbold* en a rapporté une qu'il a trouvée près du volcan d'*Imbaburra*, au royaume de *Quito*, à 1200 toises de hauteur. Elle est assez décomposée et encore enduite de cendres volcaniques. Son émail est teint en roussâtre; elle est longue de 0,12, et large de 0,085. Voyez pl. II [67], fig. 1." (De Blainville, 1839–1864, p. 249): "Cette espèce a été proposée, pour la première fois, par M. G. Cuvier, en 1806, dans son mémoire sur différentes dents de Mastodontes. Ann. du Mus., tome VIII, p. 411, et dans les mémoires réunis tome I, p. 11 [tome II, 1812.1, p. 11], et enfin dans la seconde édition de ses Recherches sur les Ossements fossiles de Quadrupèdes (tome I, p. 266, 1821 à 1825). Elle ne reposait et ne repose encore que sur un petit nombre de pièces, trois dents molaires. (*Loc. cit.*, pl. 2, fig. 1 et fig. 12.)"

= *Cordillerion andium* of the present Memoir.

Mastodonte humboldien, la plus petite, Cuvier, 1806.3, p. 413 = *Mastodon Humboldtii* Cuv. (see Desmarest, 1818, p. 447); *M. humboldii* Cuvier, 1821–1824, Vol. V, Pt. 2, p. 527). TYPE.—Cuvier, 1806.3, Pl. 67 [II], fig. 5; confirmed by de Blainville (1839–1864, p. 249). TYPE LOCALITY.—Near Concepcion, Chile. TYPE DESCRIPTION.—(Cuvier, 1806.3, p. 412): "M. *de Humbold* est encore celui qui les a découvertes. Je lui en dois une qu'il a rapportée de la *Conception* du *Chili;* elle est fort usée, mais bien conservée, teinte en noir, longue de 0,08, et large de 0,06. Voyez pl. II [67], fig. 5."

= *Cuvieronius humboldtii* of the present Memoir.

3. THE ZYGOLOPHODONTINÆ: SEPARATION BY SCHINZ AND VACEK FROM THE LONGIROSTRINÆ

(1) One of the earliest revisions of the mastodonts, in the broad sense, following Cuvier, is that of Desmarest (1820–1822) in which all of Cuvier's five species are reviewed and the name *Mastodon cordillerarum* applied to Cuvier's *Mastodonte des Cordilières.* In this revision six species of *'Mastodon'* are recognized, namely, *Mastodon giganteum, M. angustidens, M. cordillerarum* Desm. (=*M. andium* Cuv.), *M. Humboldtii, M. minus* (=*M. angustidens*), and *M. tapiroides* (pp. 384–386). *M. minus* (=*minutus*) is a synonym of *M. angustidens.*

(2) The next revision is that of Schinz (1824, p. 278), in which five of the same species are recognized and the zygolophodont species *'Mastodon turicense'* from the lignites of Elgg, Canton Zurich, is added.

(3) There followed successive revisions in which it was recognized that *M. tapiroides* Cuv. and *M. turicensis* Schinz, animals possessing lophodont grinders *without* trefoils (=Zygolophodontinæ), should be separated off from animals possessing bunomastodont grinders *with* trefoils (=Bunomastodontidæ), namely, *M. angustidens* and *M. longirostris.*

(4) Finally, in 1879, Lortet and Chantre distinguished two groups of species, separating in group II (=Zygolophodontinæ Osborn), "Mastodontes à dents présentant des collines larges et tapiroides," the following (p. 304):

II Lortet and Chantre (1879)	(Present Memoir, 1927)
Mastodon Borsoni Hays, 1834	=*Zygolophodon borsoni*
Mastodon Turicensis Meyer, 1839	=*Turicius turicensis*
Mastodon Tapiroides de Blainville, 1839	=*Turicius tapiroides*
Mastodon Buffonis Pomel	=*Zygolophodon borsoni buffonis*
Mastodon Vellavus Aymard, 1846	=*Zygolophodon borsoni vellavus*
Mastodon Vialetti Aymard, 1846	=*Zygolophodon borsoni vialetii*

(5) Practically the same zygolophodont phylum is adopted by Mayet (1909, p. 45) who, with Depéret, enjoys the advantage of direct examination and comparison of the type and referred specimens included within Mayet's Section B "Mastodontes à Mamelons Disposes en Crêtes Transversales (Type Lophodonte)." These species, namely, *Mastodon borsoni, M. turicensis, M. tapiroides,* [and *M. pyrenaicus*], are those chosen by the Austrian palæontologist M. Vacek in 1877 as typical of the genus *Zygolophodon.*

Bunolophodont and Zygolophodont Miocene and Pliocene Species of Europe after Mayet, 1909

A. — MASTODONTES A MAMELONS ARRONDIS (TYPE BUNODONTE)

Mastodon angustidens Cuvier.

1825. ***Mastodon angustidens.*** Cuvier, *Ossements fossiles,* t. I, p. 250.
1825. ***Mastodon minutus.*** Cuvier, *Id.,* p. 267, pl. II, fig. 11.
1851. ***Mastodon Simorrense.*** Lartet, *Notice sur la colline de Sansan,* p. 24.
1851. ***Mastodon Gaujaci.*** Lartet, *Id.,* p. 24.
1854. ***Mastodon Cuvieri.*** Pomel, *Catalogue méthodique,* p. 76.
1859. ***Mastodon angustidens.*** Lartet, Note sur la dentition des proboscidiens vivants et fossiles *(Bulletin de la Société géologique de France,* 1859, p. 469, pl. XVI, fig. 1-4; pl. XX, fig. 6).
1859. ***Mastodon angustidens.*** P. Gervais, *Zoologie et Paléontologie françaises,* 2e édit.
1870. ***Mastodon arvernensis.*** Fraas, *Die Fauna von Steinheim,* Stuttgart, 1870.
1887. ***Mastodon angustidens.*** Depéret, Vertébrés miocènes de la vallée du Rhône *(Archives du Muséum d'histoire naturelle de Lyon,* t. IV [1]).
1898. ***Mastodon angustidens.*** Mayet, Mammifères miocènes des sables de l'Orléanais et des faluns de la Touraine *(Annales de l'Université de Lyon,* fasc. 24); — des sables de l'Orléanais, p. 140, pl. VII, fig. 3, 4, 5, 6; — des faluns du Blésois, p. 297, pl. XI, fig. 2 et 3).

Species, including types and referred specimens, related to the *Mastodon angustidens* phylum. After Mayet, 1909, p. 44.

[=Longirostrinæ and Brevirostrinæ of the present Memoir]

B. — MASTODONTES A MAMELONS DISPOSES EN CRÊTES TRANSVERSALES (TYPE LOPHODONTE)

Mastodon turicensis Schinz.

1825. ***Mastodon tapiroïdes.*** Cuvier, *Ossements fossiles,* t. 1, p. 267, pl. III, fig. 6. Cf. aussi Guettard, *Mémoires,* t. VI, 10e m., pl. VII, fig. 4.
1827. ***Mastodon turicensis.*** Schinz, *Naturg. und Abbild. d. Säugethiere,* 1827, p. 243.
1842. ***Mastodon turicensis.*** H. von Meyer, *Palæontologica zur Geschichte der Erde und ihrer Geschopfe,* Francfort.
1850. ***Mastodon tapiroïdes.*** Blainville, *Ostéographie,* G. Eléphant.
1859. ***Mastodon Borsonii.*** G. Gervais (p. part.), *Zoologie et Paléontologie françaises,* 2e éd., p. 68.
1878. ***Mastodon affinis.*** Jourdan, *Archives du Muséum de Lyon,* t. II.
1878. ***Mastodon tapiroïdes.*** Lortet et Chantre, Recherches sur les Mastodontes *(Archives du Muséum de Lyon,* t. II, p. 285, pl. VII et IX).
1887. ***Mastodon turicensis.*** Depéret, Vertébrés miocènes de la vallée du Rhône *(Archives du Muséum de Lyon,* t. IV, p. 131).
1908. ***Mastodon turicensis.*** L. Mayet, Mammifères miocènes des sables de l'Orléanais et des faluns de la Touraine *(Annales de l'Université de Lyon,* fasc. 24); — des sables de l'Orléanais, p. 194, pl. VIII, fig. 1 et 2; — des faluns du Blésois p. 298, pl. XI, fig. 4 et 5.

Type and referred species related to the *Mastodon turicensis* phylum. After Mayet, 1909, p. 45.

[=Zygolophodontinæ of the present Memoir]

(6) In Vacek's invaluable Memoir of 1877, "Über Österreichische Mastodonten," we not only find a clear separation of the Zygolophodontinæ from the Longirostrinæ (*Trilophodon*, *Tetralophodon*, etc.), but a clear separation of the Brevirostrinæ (*Anancus*, etc.) from the Longirostrinæ. Vacek's classic memoir is fully treated in Chapter VII (the Zygolophodontinæ).

4. THE BREVIROSTRINÆ: SEPARATION BY LORTET AND CHANTRE FROM THE LONGIROSTRINÆ AND ZYGOLOPHODONTINÆ

Following Cuvier, in a long period of exploration, discovery, and research, representatives were found of a new and important phylum, unknown to Cuvier, namely, the Brevirostrinæ, including '*Mastodon*' *arvernensis* of Auvergne and related forms, while many additional members of the phyla known to Cuvier were discovered and traced into genera by Falconer.

The state of knowledge and opinion in 1878 is reflected in the splendid memoir "Recherches sur Les Mastodontes" of Lortet and Chantre, 1879, pp. 285–311, Pls. I–XVI (bis). In this invaluable memoir the mastodonts are grouped as follows:

I

MASTODONTES À DENTS ÉTROITES

MASTODONTES DISSIMILIS, Jourdan

[p. 297]

Mastodon dissimilis.....Jourdan, 1840.
" *Arvernensis*....Croizet et Jobert, 1828.
" *Arvernensis*....de Blainville, 1839.
" *angustidens*....Cuvier, 1836.....(*pro parte*).
" *angustidens*....de Blainville, 1839..(*pro parte*).
" *angustidens*....Laurillard, 1846.....(*pro parte*).
" *brevirostris*.....P. Gervais, 1859.
Anancus macroplus.....Aymard, 1846.

[=Brevirostrinæ and Longirostrinæ of the present Memoir]

MASTODON LONGIROSTRIS, Kaup

[p. 303]

Mastodon longirostris.....Kaup, 1835.
" *angustidens*....de Blainville, 1839....(*pro parte*).
" *angustidens*....P. Gervais, 1859.....(*pro parte*).
" *longirostris*.....Owen, 1861.
" *longirostris*.....H. v. Meyer, 1867.
" *longirostris*.....Falconer, 1868.
" *longirostris*.....Vacek, 1877.

[=Longirostrinæ and Tetralophodontinæ of the present Memoir]

II

MASTODONTES À DENTS PRÉSENTANT DES COLLINES LARGES ET TAPIROIDES

MASTODON BORSONI, Hays

[p. 304]

Mastodon Borsoni.....Hays, 1834.
" *Turicensis*.....H. v. Meyer, 1839.
" *Tapiroides*.....de Blainville, 1839....(*pro parte*)
" *Borsoni*.....de Blainville, 1839.
" *Buffonis*.....Pomel.
" *Vellavus*.....Aymard, 1846.
" *Vialetti*.....Aymard, [1846].
" *Borsoni*.....Vacek, 1877.
" *Borsoni*.....Lartet, 1859.

[=Zygolophodontinæ of the present Memoir]

It will be observed that while Lortet and Chantre (1879) follow Cuvier in uniting the brevirostrine, longirostrine, and zygolophodontine mastodonts into the single genus '*Mastodon*,' they practically separate the species into three groups which correspond respectively with the subfamilies Brevirostrinæ, Longirostrinæ, and Zygolophodontinæ of the present Memoir.

Consequently the grouping of species by Lortet and Chantre (1879) is nearer the truth than that of Mayet (1909), because Mayet includes under his Group A, "Mastodontes à Mamelons Arrondis (Type Bunodonte)," species belonging in both the Longirostrine and Brevirostrine phyla, while he rightly includes in his Group B.

"Mastodontes à Mamelons Disposes en Crêtes Transversales (Type Lophodonte)," the entire Zygolophodontine phylum.

In the Miocene of Europe no representatives of the Brevirostrinæ have been found, but this phylum is apparently represented in the Pliocene of India, e.g., *Anancus perimensis*. The author has not yet had an opportunity of personally examining the classic collections of the Proboscidea of Miocene Europe, which must be very carefully reëxamined before their true phyletic, generic, and specific characters can be determined. We have positive evidence of the existence of four entirely separate and distinct proboscidean lines of descent, and we see some evidence of the existence of a fifth line in Miocene Europe, although the fifth phylum has not been positively demonstrated as yet. These theoretical lines[1] are as follows:

I	II	III	IV	V(?)
MASTODONTIDÆ		BUNOMASTODONTIDÆ		ELEPHANTIDÆ
MASTODONTINÆ descended from *Miomastodon* *Pliomastodon*	ZYGOLOPHODONTINÆ perhaps a branch of *Zygolophodon* *Turicius*	LONGIROSTRINÆ descended from *Phiomia* *Trilophodon* *Tetralophodon*	SERRIDENTINÆ perhaps a branch of *Phiomia* *Serridentinus* (?)	STEGODONTINÆ a branch of unknown ancestors [*Stegolophodon*]

These four to five subfamilies are represented by species of Miocene and Pliocene age as follows:

1. Mastodontinæ by species of *Miomastodon* and *Pliomastodon*, e.g., *Miomastodon tapiroides americanus* and *Pliomastodon americanus praetypica.*
2. Zygolophodontinæ by the species *Turicius tapiroides, T. turicensis,* and *Zygolophodon borsoni.*
3. Longirostrinæ by the species *Trilophodon angustidens;* all longirostral types.
4. Serridentinæ, *medilongirostral* Serridentines with medium length of jaw, specifically defined by *Serridentinus filholi* in Europe; represented in Asia by *S. mongoliensis;* in America by *S. productus, S. serridens,* and other species.
5. Stegodontinæ (i.e., ancestors of) possibly represented by a species, *Zygolophodon* [=*Stegolophodon*] *sublatidens,* recently described by Schlesinger from eastern Europe.

5. THE ZYGOLOPHODONTINÆ (=MASTODON BORSONI): FINAL SEPARATION (RUSSIA, 1894) FROM THE MASTODONTINÆ (=MASTODON AMERICANUS)

It appears, from Marie Pavlow's revision (1894) cited below, that all Russian students of the Proboscidea worked under the spell of Cuvier and conservatively adhered to his generic name *Mastodon* even though they clearly recognized the wide distinctions which exist between the genotype species *Mastodon americanus* and many other species which he included within this genus. As detailed above, the last phylum to be split off from the Mastodontinæ of the true *Mastodon americanus* type is that embracing a large number of European and Asiatic species which may be grouped under the name Zygolophodontinæ. Beginning in 1824 with the discovery of *Mastodon turicensis* and continuing in 1834 with the recognition of *M. borsoni,* this important and entirely distinct phylum, the Zygolophodontinæ, was gradually recognized, until in 1877 Vacek proposed the generic name *Zygolophodon.*

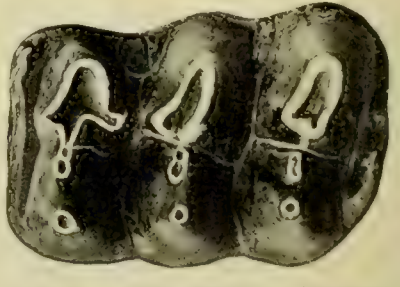


Fig. 81. Tooth referred to '*Mastodon ohioticus*' by Pavlow, from Pestchana, Podolia, Russia. (Pavlow, 1894, Pl. 1): "Fig. 4, une m^2 [M_2] inférieure droite . . ." Univ. de Moscou. [=*M.* (?)*pavlowi* ref.] That this is a true species of the true genus *Mastodon* appears from the two principal 'mamelons' composing each crest.

[1](Osborn, 1931). These theoretical lines of generic descent are considerably modified in the Appendix of the present Volume.

6. SEPARATION OF SPECIES OF 'MASTODON' AND 'ELEPHAS' DESCRIBED IN AMERICA (1792–1874)

The American palæontologists up to the year 1878 were no less conservative than their European confrères in retaining the two generic names *Mastodon* and *Elephas* for all kinds and forms of proboscideans. The new generic names *Euelephas*, *Tetralophodon*, and *Trilophodon* of Falconer were reluctantly admitted only by certain authors. Between 1884 and 1922, however, the tendency to split the mastodonts into a number of genera did not assert itself generally until Osborn began the present revision, as shown in the following chronological list of names as originally used and as revised in the present Memoir.

Original Generic and Specific Names Applied to Species of Mastodonts	Generic and Specific Names as Revised by Osborn in the Present Memoir	Subfamily Phyla to the Year 1927
1792 *Elephas americanus* Kerr.	*Mastodon americanus*	Mastodontinæ
1834 *Mastodon borsoni* Hays	*Zygolophodon borsoni*	Zygolophodontinæ
1834 *Mastodon chapmani* Hays	*Stegomastodon chapmani*	[Humboldtinæ subfam. nov.]
1838 *Elephas jacksoni* Mather	*Parelephas jacksoni*	Mammontinæ
1842 *Elephas americanus* De Kay	*Mammonteus primigenius americanus*	Mammontinæ
1857–1868 *Elephas columbi* Falconer	*Parelephas columbi*	Mammontinæ
1858 *Mastodon (Tetralophodon) mirificus* Leidy	*Stegomastodon mirificus*	[Humboldtinæ subfam. nov.]
1858 *Elephas imperator* Leidy	*Archidiskodon imperator*	Mammontinæ
1859–1861 *Elephas texianus* Owen 1859, and Blake, 1861	*Parelephas columbi*	Mammontinæ
1868 *Mastodon americanus* Leidy	*Mastodon americanus*	Mastodontinæ
1869 *Mastodon obscurus* Leidy	*Trilophodon obscurus*	Longirostrinæ
1871 *Mastodon shepardi* Leidy	*Rhynchotherium shepardi*	Rhynchorostrinæ
1873 *Mastodon proavus* Cope	*Serridentinus proavus*	Serridentinæ
1874 *Mastodon productus* Cope	*Serridentinus productus*	Serridentinæ

A full list of the generic and specific synonyms of *Mastodon americanus* will be found in Chapter VI (Subfamily Mastodontinæ), under the heading of this species.

7. OSBORN'S CLASSIFICATION[1] (1927) OF THE SUPERFAMILY MASTODONTOIDEA

From the foregoing sections it appears that the collective genus '*Mastodonte*' of Cuvier, 1806, has become, through discovery, analysis, and research, equivalent to the superfamily Mastodontoidea. This superfamily, as it comprises all the mastodonts in all parts of the world, is far more comprehensive than Girard imagined in his Mastodontidæ, because it includes two families, Mastodontidæ and Bunomastodontidæ, and *not less than seven subfamilies* and seventeen genera, the number of which is constantly being enlarged.[1]

Through discoveries by Schinz (1824), by Vacek (1877), by Lortet and Chantre (1879), by Pavlow (1894), by Mayet (1909), and by Osborn (1918–1925), the seven distinct subfamily phyla, Mastodontinæ, Zygolophodontinæ, Longirostrinæ, Serridentinæ, Rhynchorostrinæ, Notorostrinæ, and Brevirostrinæ, have been separated off.

Thus the superfamily Mastodontoidea requires a definition broad enough to embrace the characters common to these seven subfamilies.

[1]This, like all other classifications of the 1927 period, is now replaced by the 1935 classification set forth in the Appendix at the close of the present Volume. See also page 11 and footnotes on pages 27, 30, and 31 above. At the present time (July, 1935) the genera included within the Mastodontoidea number twenty-nine.

SUBORDER OR SUPERFAMILY: MASTODONTOIDEA Osborn, 1921

Families:[1] Mastodontidae Girard, 1852, Osborn, 1918; Bunomastodontidæ Osborn, 1921

Original reference: Mastodontoidea Osborn, Amer. Mus. Novitates, No. 1, p. 1 (Osborn, 1921.515); Mastodontidæ Girard, Proc. Amer. Assoc. Adv. Sci., 1852, pp. 326, 328; Osborn, Bull. Geol. Soc. Amer., XXIX, 1918, p. 134 (Osborn, 1918.468). Bunomastodontidæ Osborn, Amer. Mus. Novitates, No. 1, 1921, p. 2 (Osborn, 1921.515).

DEFINITION.—Chiefly forest and savanna living proboscideans; widely migrating in the north and south temperate regions. Browsers on tree and shrub leafage and on twigs; uprooters in part. Superior and inferior incisive tusks adapted to varied food habits, branching and uprooting, and to varied modes of defense; retaining or losing enamel bands. Deciduous premolar series prevailing over permanent premolars. Intermediate molars, P4-M2, early becoming trilophodont; third molars, M^3-M_3 progressive to 4–7 crests; cones, conules or conelets progressive to lophodont, bunolophodont, or ptychodont form. Body prevailingly elongate, broad, massive, short limbed.

MASTODONTIDÆ

1. SUBFAMILY MASTODONTINÆ

Nipple-toothed mastodonts

Tusk enamel disappearing. Grinders sublophodont to subhypsodont.

[*Palæomastodon*[2]]
Mastodon
Miomastodon
Pliomastodon

1. =*Mastodon giganteum* Cuvier

2. SUBFAMILY ZYGOLOPHODONTINÆ

Yoke-toothed mastodonts

Incisive tusks oval, (?) retaining enamel band. Grinders becoming truly crested, with numerous conelets.

Zygolophodon
Turicius

2. =*Mastodon tapiroides* Cuvier

BUNOMASTODONTIDÆ

3. SUBFAMILY LONGIROSTRINÆ

Long-jawed mastodonts

Upper and lower tusks functional in feeding, superior tusks retaining enamel band, inferior tusks spatulate, losing enamel band. Grinders with central conules or conelets in valleys.

Phiomia
Trilophodon
Tetralophodon

3. =*Mastodon angustidens* Cuvier

4. SUBFAMILY SERRIDENTINÆ

Serrate-toothed mastodonts

Superior and inferior incisive tusks functional in feeding, retaining enamel band. Rostrum moderately elongate. Grinders without central conules or conelets, with external and internal serrated spurs.

Serridentinus

4. Unknown to Cuvier

BUNOMASTODONTIDÆ

5. SUBFAMILY RHYNCHOROSTRINÆ

Beak-jawed mastodonts

Superior and inferior tusks downturned, functional in feeding, retaining enamel band. Grinders with intermediate conules or conelets.

Rhynchotherium

5. Unknown to Cuvier

6. SUBFAMILY NOTOROSTRINÆ

South American mastodonts

Jaws gradually abbreviating. Superior incisive tusks purely offensive (without enamel) or used in feeding (with enamel). Grinders with intermediate conules or conelets.

Cordillerion
Cuvieronius
Eubelodon

6. =*Mastodon andium* and *M. humboldtii* Cuvier

7. SUBFAMILY BREVIROSTRINÆ

Short-jawed mastodonts

Superior tusks offensive weapons, losing enamel band; inferior incisive tusks disappearing. Grinders with alternating external and internal lobes, i.e., cones, lacking intermediate conules or conelets, developing double or quadruple trefoils.

Anancus
Pentalophodon, [*Synconolophus*]

7. Unknown to Cuvier

The above synopsis shows that in 1927 Cuvier's '*Mastodon*' was known to embrace five classic species and seven subfamilies. To these are now (1935) added seven subfamilies, making fourteen subfamilies in all (see Appendix of the present Volume I).

[1](Osborn, 1934) The suborder Mastodontoidea now includes the additional families Serridentidæ fam. nov. and Humboldtidæ fam. nov.

[2](Osborn, 1934) The subfamily relationships of [*Palæomastodon*] are now uncertain. (1935) See pages 143–149 below, also Palæomastodontinæ subfam. nov. in Appendix of the present Volume.

8. CUVIER AND THE REVOLUTIONS OF THE GLOBE

This historic chapter may appropriately conclude with quotations from "Les Transformations du Monde animal," a work published in the year 1907 by Charles Depéret, who next to Cuvier and Gaudry ranks among the leaders of the palæontology of France. Depéret ardently sets forth and defends Cuvier as the creator of comparative anatomy and of palæontology. (Depéret, 1907.2, pp. 7, 10, 13, 14, 19, and 22):

L'admiration générale suscitée dans le monde savant par la série de mémoires que G. Cuvier publia à partir de 1798 et qui furent réunis, en 1812, sous le titre de: *Recherches sur les ossements fossiles*, n'a pas diminué [*sic*] de nos jours, malgré un recul de plus d'un siècle. Tout naturaliste qui veut se familiariser avec l'organisation des animaux supérieurs vivants ou fossiles doit encore aujourd'hui commencer ses études par la lecture de cet ouvrage magistral, où se trouvent exposées, avec une clarté et une précision lumineuses, les notions fondamentales des deux sciences sœurs: l'*Anatomie comparée* et la *Paléontologie* des vertébrés. . . .

Ainsi, Cuvier a non seulement démontré la présence dans les couches sédimentaires d'une série de faunes terrestres superposées et distinctes, mais il a eu le premier, et très nettement, l'idée du *perfectionnement organique graduel* de ces faunes depuis les plus anciennes jusqu'aux plus modernes. C'est là une notion fondamentale, dont on oublie trop souvent d'attribuer le mérite à Cuvier, dans les jugements d'une sévérité excessive et souvent injuste, que les transformistes ont porté et portent encore sur les *idées cuviériennes* en matière de paléontologie philosophique. . . .

L'illustre naturaliste expose ses idées, avec sa clarté habituelle, dans l'admirable *Discours sur les révolutions du globe*, qui forme l'introduction de son grand ouvrage sur les ossements fossiles. Pour lui, les extinctions de faunes ont été à la fois complètes et brusques, provoquées par des événements géologiques violents ou *révolutions du globe*, d'un caractère de généralité assez grand, mais non cependant absolu. En faveur de cette hypothèse, Cuvier invoque de nombreux faits, d'ordre géologique, qui, pris *isolément*, et en tenant compte des documents connus à cette époque, sont d'une rigoureuse exactitude, et dont les relations réciproques seules deviennent discutables ou même inexactes. . . .

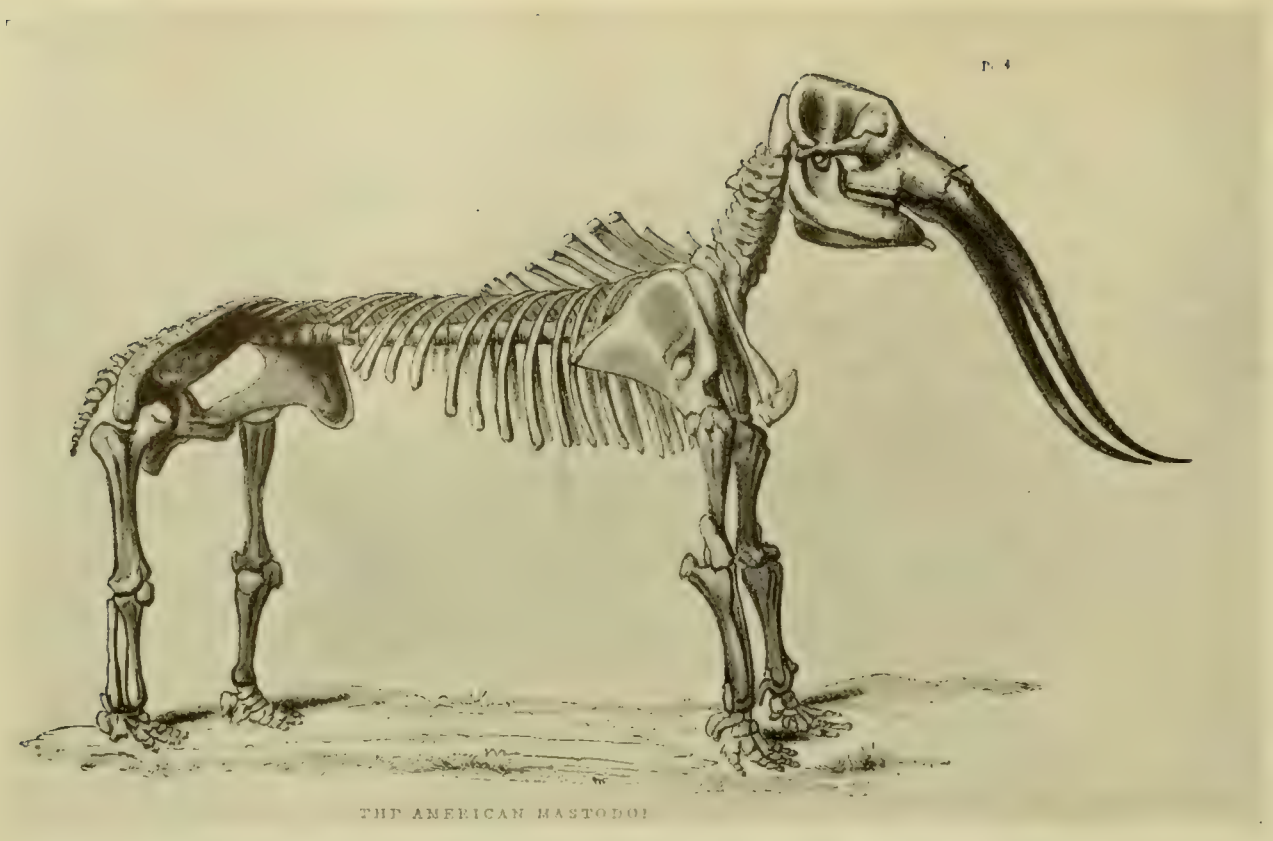
Quant au procédé de ce renouvellement, le reproche a été bien souvent adressé à Cuvier d'avoir admis à son tour une autre hypothèse tout aussi peu démontrable scientifiquement, celle des *créations successives*. Mais c'est encore là une critique tout à fait injustifiée. Nulle part, le mot de création ne se rencontre dans l'œuvre de Cuvier et il suffit de lire avec attention le *Discours sur les révolutions du globe* pour voir que dans l'esprit de l'illustre savant, il s'agit seulement d'*invasions* de nouvelles formes animales venues brusquement de contrées lointaines inconnues. Ici, l'idée est assez fondamentale pour qu'il vaille la peine de citer:

'Au reste, lorsque je soutiens,' dit Cuvier, 'que les bancs pierreux contiennent les os de plusieurs genres et les couches meubles ceux de plusieurs espèces qui n'existent plus, *je ne prétends pas qu'il ait fallu une création nouvelle pour produire les espèces existantes*, je dis seulement qu'elles n'existaient pas dans les mêmes lieux et qu'elles ont dû y venir d'ailleurs.' . . .

Le lecteur voudra bien excuser sans doute la longueur de cette citation, dont l'intérêt est considérable; elle démontre jusqu'à l'évidence qu'il faut reporter à Cuvier tout l'honneur d'avoir posé, avec une netteté et une exactitude admirables, l'hypothèse si importante et si féconde du *renouvellement des faunes par voie de migrations*. . . .

Ainsi, deux points paraissent absolument certains pour d'Orbigny: d'une part, la création en bloc de faunes entières—opinion que Cuvier n'avait jamais formulée—de l'autre, la disparition brusque de chacune de ces faunes. Pour le premier de ces grands faits, le savant paléontologiste ne tente même pas, on l'a vu plus haut, le moindre essai d'explication scientifique. . . . C'est, on le voit, la reproduction à peu près intégrale des *révolutions du globe* de Cuvier, avec une généralisation encore plus grande. . . .

Si l'explication de ce grand fait par des *créations successives* ne saurait nous satisfaire au point de vue scientifique, nous aurons plus loin à en chercher une interprétation rationnelle par des phénomènes de *migration de faunes* ou de *migration de milieux*, analogues à celles que Cuvier avait déjà si bien mis en évidence pour les animaux terrestres.



THE AMERICAN MASTODON

THE WARREN MASTODON AS IT WAS FIRST MOUNTED (1845-1846), SHORTLY AFTER ITS DISCOVERY

Fig. 82. The figure is reproduced from the *American Journal of Agriculture and Science*, Volume II, Number 2, conducted by E. Emmons, Albany, and A. J. Prime, Newburgh. In their article, "The Great American Mastodon," Messrs. Emmons and Prime remark: "The skeleton has since been arranged and set up, and this has been done with great care and the strictest attention to the articulating surfaces of all the bones, which we believe has not been the case with others which have been put together."

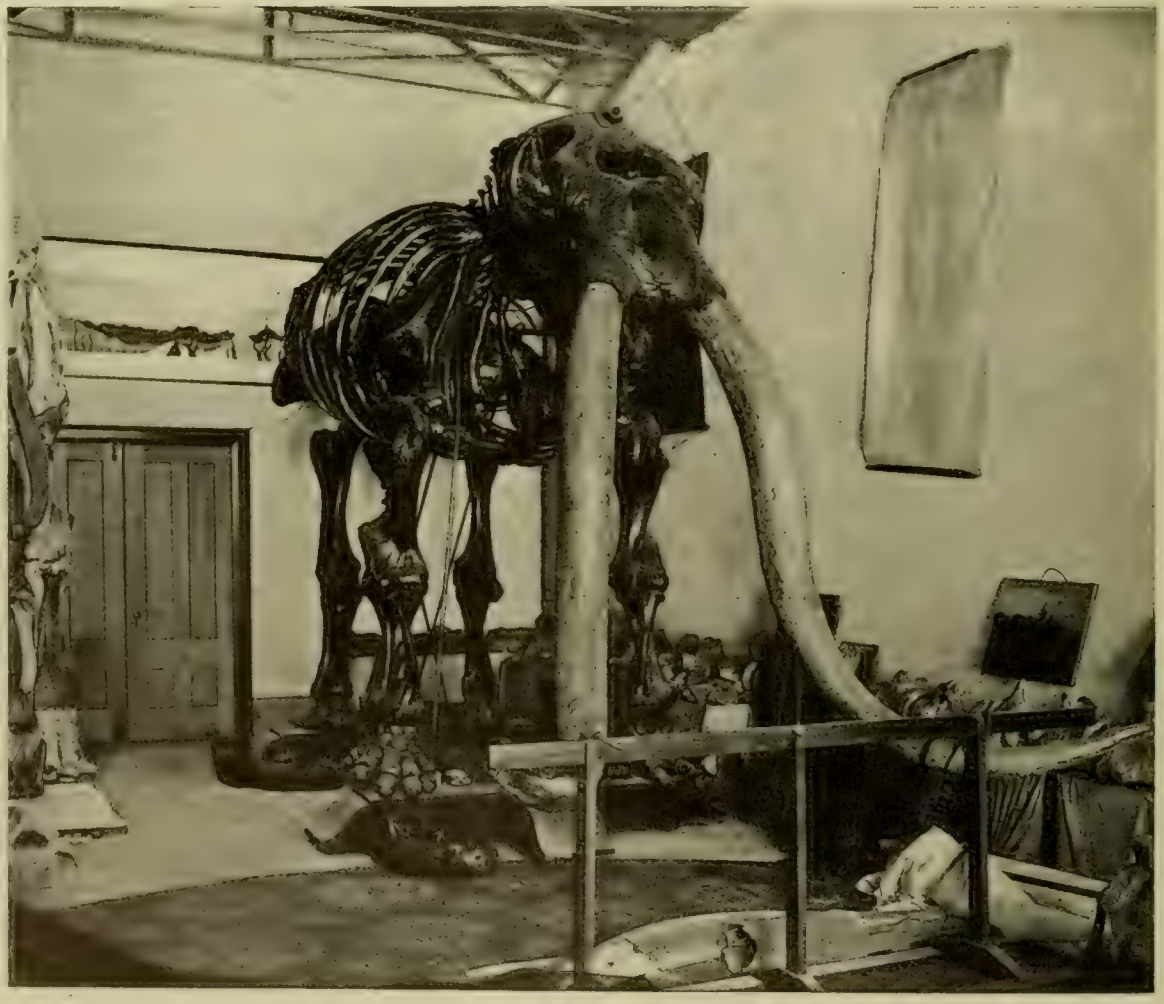
THE WARREN MASTODON AS REMOUNTED IN 1849

As photographed in the interior of the Warren Museum, 92 Chestnut Street, Boston.

Fig. 83. For fifty-seven years, 1849-1906, the Warren Mastodon, mounted as shown herewith, was exhibited in the Warren Museum in Boston. In 1906 it was acquired, thanks to the generosity of the late J. Pierpont Morgan, by the American Museum.

The skeleton, as here depicted, is covered with heavy black varnish. The imitation tusks are made of papier-mâché and were so lengthened as to sweep the ground and curve outwards at the extremities. The chest and backbone were raised two feet above the top of the shoulder blade, or scapula, and as a result the natural height of the animal was increased from nine feet to twelve feet. Beneath the Warren Mastodon are tusks and grinding teeth of other specimens. Around the base of the walls are many vertebræ of the giant *Zeuglodon*, the archaic fossil whale of the southern United States.

THE WARREN MASTODON as remounted for The American Museum of Natural History, under the direction of Curator Henry Fairfield Osborn, July, 1907, by chief preparator Adam Hermann and assistants, is shown in figure 124, page 178.



Chapter VI

HISTORY OF THE SUBFAMILY MASTODONTINÆ, THE TRUE MASTODONTS

Discovery of mastodon americanus, of pliomastodon matthewi, of miomastodon merriami, and of palæomastodon beadnelli. Subfamily, generic, and specific distinctions. Habitat, migrations, phylogenetic succession, and extinction of the mastodontinæ.

1. History of the subfamily Mastodontinæ, 1705–1934.
2. Résumé of the subfamily characters.
3. Separation of mastodonts of the *Mastodon americanus* and *Zygolophodon borsoni* phyla in Russia.
4. Résumé of discovery and description of the Mastodontinæ.
5. Progressive characters and generic distinctions of the Mastodontinæ.
6. Characters of *Palæomastodon* and its included species.
7. Characters of *Miomastodon* and its included species.
8. Characters of *Pliomastodon* and its included species.
9. Historical review of the discovery of the genus *Mastodon* (1705–1934) and of the species *Mastodon americanus* (1792–1869).
10. Characters of *Mastodon* and its included species and varieties.
11. Skeletal characters of Warren and Whitfield mastodons.
12. Age and progressive cranial and dental characters of *Mastodon americanus*, revealed in the American Museum collections.

In Chapter II it is shown how the Mastodontoidea may be clearly distinguished from the Mœritherioidea, the Deinotherioidea, and the Elephantoidea. In Chapter V it is shown how Cuvier's original genus '*Mastodonte*' (=*Mastodon*) came to embrace two[1] distinct families, seven[1] distinct subfamily phyla, and seventeen[1] distinct genera. In the present Chapter VI Cuvier's genus *Mastodon*, based on the type *Mastodon americanus*, becomes the terminal member of the subfamily Mastodontinæ, otherwise known as the 'true mastodonts,' with a geologically prolonged lineage of its own certainly traceable into Asia and Europe and possibly back to the Lower Oligocene *Palæomastodon* of North Africa. Accordingly *Palæomastodon* is systematically treated in this chapter, and the reader is referred to Chapter II where *Palæomastodon* is described in its North African environment of Oligocene time in competition with *Mœritherium* and *Phiomia*. The discovery of a complete cranium and jaws may compel us to remove *Palæomastodon* from the subfamily Mastodontinæ[2], in which it now rests on the evidence at present available. It is certainly not a direct ancestor of *Mastodon*.

(October, 1934) The very important addition of the Lower Miocene *Miomastodon depereti* sp. nov., from the Sables de l'Orléanais of France, of the *Mastodon pavlowi* sp. nov., from Pestchana, Podolia, Russia, has recently been made to the subfamily Mastodontinæ, as described in the phylogenetic appendix of the present Volume; see fig. 230D, p. 284, of Chap. VIII, and Pl. I, p. 134; also of the *Mastodon acutidens* sp. nov. of the Pleistocene of North America (see Figs. 131 A1–A4, 135, and Pl. I, also Appendix).

1. HISTORY OF THE SUBFAMILY MASTODONTINÆ, 1705–1934

Original reference: Mastodontina Brandt, 1869, Mém. Acad. Imp. Sci. St. Petersb., (VII), XIV, No. 1, p. 35. Mastodontinæ Osborn, 1910, "The Age of Mammals," p. 558 (Osborn, 1910.346).

Although the first fossil remains of a member of this great subfamily were discovered on the banks of the Hudson River as early as 1705, also near the banks of the Ohio River (Big-Bone Lick, Kentucky) by the Indians who gave them in 1739 to a French officer named Longueil, the origin, migrations, and early geologic history of the Mastodontinæ are still comparatively obscure.

This we believe is because the Mastodontinæ have included forest-living animals from the very beginning of their history, for fossil remains of forest-living animals are always rare in Tertiary deposits.

Only by such a forest-loving hypothesis can we explain the unparalleled abundance of the remains of *Mastodon americanus* in the ancient forest, bog, and swamp deposits of the eastern and middle United States, as

[1]See page 128.

[2]See pages 143–149 below, also Palæomastodontinæ in Appendix.

summarized in the nation-wide records collected by Dr. J. M. Clarke, Dr. O. P. Hay, and others. And only by this hypothesis also can we explain the abundance and remarkable preservation of the more or less complete skeletons of our American Mastodon, which we believe outnumber those of all other extinct proboscideans put together.

Mastodon.—In the northern portions of the American continent these remains become very rare, and as we pass westward into the plains region and northward into Eurasia not a single fossil record is found until we reach Podolia, Russia, from which locality Marie Pavlow in 1894 described a single tooth (Fig. 81) which she referred to '*Mastodon ohioticus*.' This central Eurasiatic region also yields teeth of the species belonging to the related subfamily Zygolophodontinæ. When the grinders of *Mastodon americanus* are placed side by side with those of *Zygolophodon borsoni* we observe that they are really profoundly different; we verify this observation as we proceed westward into Austria, Germany, and France and discover that the bilobed grinding tooth of the true *Mastodon* may be traced back into its simple ancestral forms, which are quite distinct from the quadrilobed grinding tooth of the true *Zygolophodon*.

Miomastodon.—This new stage of ancestral *Mastodon* grinder, as it appears in the Miocene of Holarctica, is placed in the distinct genus *Miomastodon* Osborn, because with these simple grinders are associated upper incisive tusks with *broad enamel band;* no Lower Pleistocene *Mastodon* thus far discovered has the enamel band. Thus the Pleistocene *Mastodon americanus* certainly leads back into the Miocene *Miomastodon* of western Eurasia and of North America. An intermediate stage is the Pliocene *Pliomastodon* lacking the enamel band.

Palæomastodon.—Somewhat doubtful at present is the theory advanced by Matsumoto, and more recently supported by Osborn, that the original ancestor[1] of the Mastodontinæ is to be found in the true *Palæomastodon* (as distinguished from the longirostral *Phiomia*) which occurs with relative rarity in the Oligocene river sands of the Fayûm of northern Africa. Fossil remains of *Palæomastodon* are relatively rare, the skull is little known, but so far as our present knowledge goes the *Palæomastodon* grinding teeth are not ancestral in type to those of the true American Mastodon.

2. RÉSUMÉ OF THE SUBFAMILY CHARACTERS

Subfamily Characters.—Skull brachycephalic, brachyopic; cranium relatively broad and low. Mandibular rami rapidly abbreviating, with persistently rounded inferior tusks becoming variable. Superior tusks rounded, with enamel band in the *Palæomastodon*[1] and *Miomastodon* stages disappearing in the Upper Pliocene (*Pliomastodon*) and Pleistocene (true *Mastodon*) stages; superior tusks upturned and out-turned, adapted to browsing and uprooting purposes, powerful offensive and defensive weapons. Grinding teeth hexabunodont in *Palæomastodon*, primitively tetrabunodont in *Miomastodon* and *Mastodon* by the absence of the intermediate conules, gradually acquiring a bunolophodont form; intermediate grinders, Dp^4-Dp_4, M^1-M_1, M^2-M_2, becoming trilophodont; third superior grinders, M^3, progressive to tetralophodont stage only; third inferior grinders progressive to tetralophodont + or four and a half ridge-crests only.

Warning the reader of the present limitations of our knowledge, which chiefly arise from the very great rarity of fossil materials in the Eastern Hemisphere, we may give a theoretic summary of the ancestral history of the Mastodontinæ.

Geographic and Geologic Range.—Springing from unknown ancestors of the Eocene-Oligocene of North Africa, the true Mastodontinæ appear in the Lower Miocene *Miomastodon* of western Eurasia and soon find their way eastward into North America, appearing in the Middle Miocene species of Nevada, *Miomastodon merriami*,

[1]See footnotes on pages 36 and 131.

and in the Lower Pliocene species of western Nebraska, *Pliomastodon matthewi*, meanwhile leaving behind in Austria-Hungary their relatives, *Miomastodon tapiroides americanus* and *Pliomastodon americanus praetypica*, which give rise to the rare true *Mastodon* of southern Russia, referred to '*Mastodon ohioticus*' by Pavlow. Rarely found in northern and western North America, they multiply rapidly in the favorable forests of the middle and eastern United States in the typical form *Mastodon americanus*.

Subfamily Habital Adaptation.—These broad, massive, low-bodied, low-headed, well-defended Mastodontinæ probably evolved chiefly in the north temperate forests of Eurasia and of North America avoiding the extremes of warm climate in both hemispheres. The American Mastodon is known to have lived on the foliage of trees and shrubs aided by the vertical chopping motion of its jaws and the free interlocking action of its superior and inferior ridge-crests, the valleys not being filled or blocked with the trefoils, as in the valleys of the Longirostrinæ molar. That these true mastodonts were temperate and cold-loving animals, enjoying coniferous herbage, is shown by their avoidance of southern Eurasia, where no trace of the subfamily is found, also by their early disappearance in northern Africa.

3. SEPARATION OF MASTODONTS OF THE MASTODON AMERICANUS AND ZYGOLOPHODON BORSONI PHYLA IN RUSSIA

The reader is referred to Chapter V for the history of the separation of the Zygolophodonts in Europe as distinguished from their separation in Russia. See also Pls. I, II, and III, between pp. 134–135 of the present Chapter.

We owe to the learned Russian palæontologist Marie Pavlow the full historic record, from the time of Buffon, of the occurrence of the true *Mastodon* (*ohioticus*) *americanus* in Russia and its clear distinction from the true *Zygolophodon borsoni* of Russia, a molar of which was presented to the great French naturalist Buffon in 1770 and beautifully decsribed and figured by him in 1778 (Fig. 84A).

Pavlow, 1894, pp. 1, 2, 36.—Avant d'aborder la description de tous ces restes fossiles, il me semble nécessaire de faire une courte revue de la littérature sur ce qui est connu jusqu'à présent comme restes de *Mastodon* en Russie . . . [1] Buffon. en 1775 [1], a été le premier à décrire [Footnote: 'Buffon. Epoques de la Nature. 1775. Pl. I-III.'] deux dents provenant de la Russie, et rapportées plus tard par Lartet au *Mastodon Borsoni*. Une d'elles que le comte de Vergennes lui avait donné en 1770 (l. c. Pl. I et II) a été indiquée comme trouvée dans la *Petite-Tartarie* [Footnote: 'On désignait par ce nom à la fin du XVIII siècle toute la Nouvelle Russie d'aujourd'hui.']. Une autre dent, apportée par l'abbé Chappe de *Sibérie* (Pl. III), a éveillé un grand doute sur sa provenance.

[2] Buffon, sans indiquer le genre auquel ont appartenu ces dents, les croit identiques à celles trouvées près de l'*Ohio* et ne doute pas qu'il y avait un animal inconnu jusqu'alors et commun aux deux continents. Ces échantillons types se trouvent maintenant dans la Grande Galerie du Museum à Paris.

[3] Presque en même temps Pallas a décrit, en 1770–77 [Footnote: 'Pallas. Acta Acad. Petropolitanae. 1777. Pl. 9.'] une dent très usée et trouvée dans les sables ferrugineux, près de *Belaja*, affluent de la Kama. Pallas rapprochait cette dent de celles de l'animal de l'Ohio et plus tard Blainville et Eichwald [Footnote: 'Blainville. Ostéographie. Eichwald. Paléontologie de la Russie.'] l'ont rapportée au *Mastodon tapiroides*. Le dernier de ces savants indique que cette dent se trouve à l'Institut de Mines à St. Pétersbourg.

[4] Il me semble que, autant qu'on peut en juger d'après le dessin de ce débris très mal conservé, cette dent a du appartenir à un *Mastodon* du type 'Zigolophodon', c'est à dire possédant des crêtes absolument nettes, dépourvues de mamelons intermédiaires. Ce type est le mieux représenté par *Mastodon Borsoni*.

[5] Soixante ans à peu prés se sont écoulés après cette description de Pallas, sans que personne mentionne des mastodontes trouvés en Russie, et ce n'est que depuis 1835, que des nouvelles trouvailles et des descriptions ont été faites.

[1] In the bibliography Pavlow gives the reference as follows: "Buffon. Supplément à l'histoire naturelle. Epoques de la nature. Tome V. Pl. 1–5, 1778."

[6] Ainsi Fischer de Waldheim en 1835, en déterminant d'après les dessins les fossiles trouvés près de *Riazan*, indique dans une courte notice [Footnote: 'Fischer de Waldheim. Bull. Natur. Moscou p. 394, Pl. x.'] une jeune dent d'un *Mastodon* qu'il considère comme la première trouvaille de ce genre faite en Russie. Le dessin n'est pas assez bien fait, pour pouvoir déterminer l'espèce de ce Mastodon. L'échantillon est indiqué comme se trouvant dans la collection du Lycée de Riazan....

[7. *Op. cit.*, p. 36]: Age géologique et répartition géografique du groupe Zygolophodon. L'âge géologique de ce groupe des Mastodon est bien prolongé. On rencontre leurs différents représentants depuis le *miocène*, durant le *pliocène*, en Europe et le *pleistocène* en Amérique. Les formes les plus anciennes ont été indiquées en Espagne (*Mast. tapiroides*) dans les lignites de Brihuega dans le miocène moyen (ou inférieur—Lartet p. 475 l. cit.). Dans le *miocène moyen* elles abondent: la France en a deux représentants: *Mast. tapiroides* Lartet et *Mast. turicensis* Schinz (af. *Borsoni*), dans les faluns de Touraine, graviers d'Orléanais, lignites de Soblay (Ain).

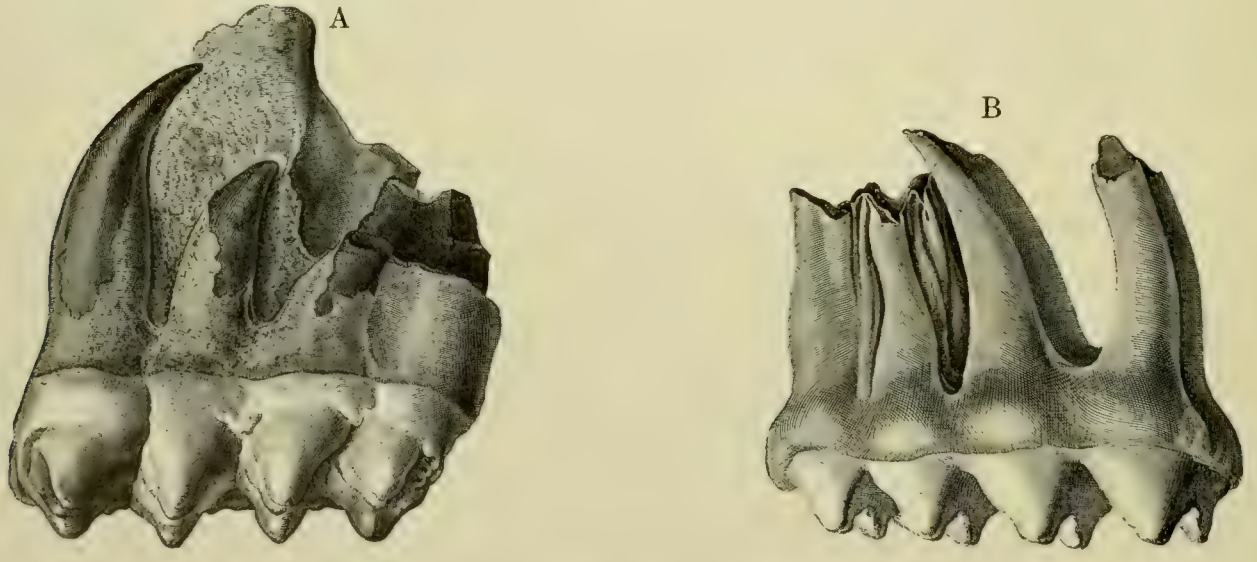
[8] *Mast. turicensis* Vacek (af. *Borsoni*) a été trouvé en Silésie. Le *miocène* en Suisse (Elgg) et la molasse de Winterthur sont très riches en *Mast. turicensis* Schinz (af. *Borsoni*), ainsi que le *mio-pliocène* d'Europe qui débute à Oeningen (Suisse).

[9] *Mast. Borsoni* Lartet, et *Borsoni* Hays provient du *Pliocène* inférieur d'Asti, d'Auray. Celui de Bravard, Lortet et Chantre du *Pliocène supérieur* du Puy-de-Dôme, Auvergne. Celui de Mr. Forsyth Major du *Pliocène supérieur* du Val d'Arno.

[10] Le *Mast. virgatidens* de v. Meyer n'est désigné que comme provenant des dépôts tertiaires de Foulda (Allemagne) sans que l'âge soit précisé.

[11] Les différentes dents de *M. Borsoni* Vacek proviennent de divers dépôts; ainsi, Pl. vi, f. 3 indiquée comme provenant du *miocène supérieur* de Neidorf éveille les doutes de l'auteur sur l'exactitude de cette indication, à cause de l'ancienneté des dépôts. Pourtant cela ne nous parait pas impossible, prenant en considération la trouvaille de *M. turicensis* Schinz dans ces dépôts et la parenté, presque l'identité de ces 2 formes.

[12. *Op. cit.*, p. 37] *Quant au rapport génétique* de ces formes il nous semble possible d'exprimer les suppositions suivantes: a) que *Mast. tapiroides* Lartet (non Schinz) de Simorre est l'espèce la plus ancienne dans ce groupe, et qui a donné naissance à b) *Mast. turicensis* et *Borsoni* de Touraine, de Soblay, de Zurich et d'Asti, laquelle à son tour a précédé c) *Mast.* aff. *Borsoni* de l'Auvergne, de l'Allemagne, de l'Autriche et de la Russie; et qu'une branche, qui a dû se détacher de ce dernier à la fin du Miocène (aff. ohioticus), a donné les formes de d) *Mast. ohioticus* de la Russie, développées dans le Pliocène.



Buffon, 1778. Superior Grinding Teeth of Zygolophodon (left) and of Mastodon (right). Originals said to be in the Paris Museum (fide Pavlow, 1894)

Fig. 84. Grinding teeth of *Zygolophodon borsoni* referred (left) and of *Mastodon americanus* referred (right), after Buffon, 1778, Pls. I and IV, one-fourth natural size. [Inverted by H. F. O.]

A, Buffon's figure of the molar of an animal which we now know to be related to *Mastodon* [=*Zygolophodon*] *borsoni*, found in Russia ("la petite Tartarie"), presented to Buffon in 1770 by M. le Comte de Vergennes. Observe three to four lobes, i.e., cones or conelets, in each transverse crest.

B, Buffon's figure of the molar of an animal now known as *Mastodon americanus*, from Big-Bone Lick, Kentucky, near the Ohio River, sent to Buffon by M. Collinson. Observe two lobes, i.e., cones, in each transverse crest, the true *Mastodon* type.

Both of these beautifully engraved molar teeth appear to be third superior grinders, M^3, although they lack the rudimentary fifth crest or pentaloph characteristic of the third superior molars of *Mastodon americanus* (Fig. 133).

PLIOMASTODON, MIOMASTODON, AND MASTODON

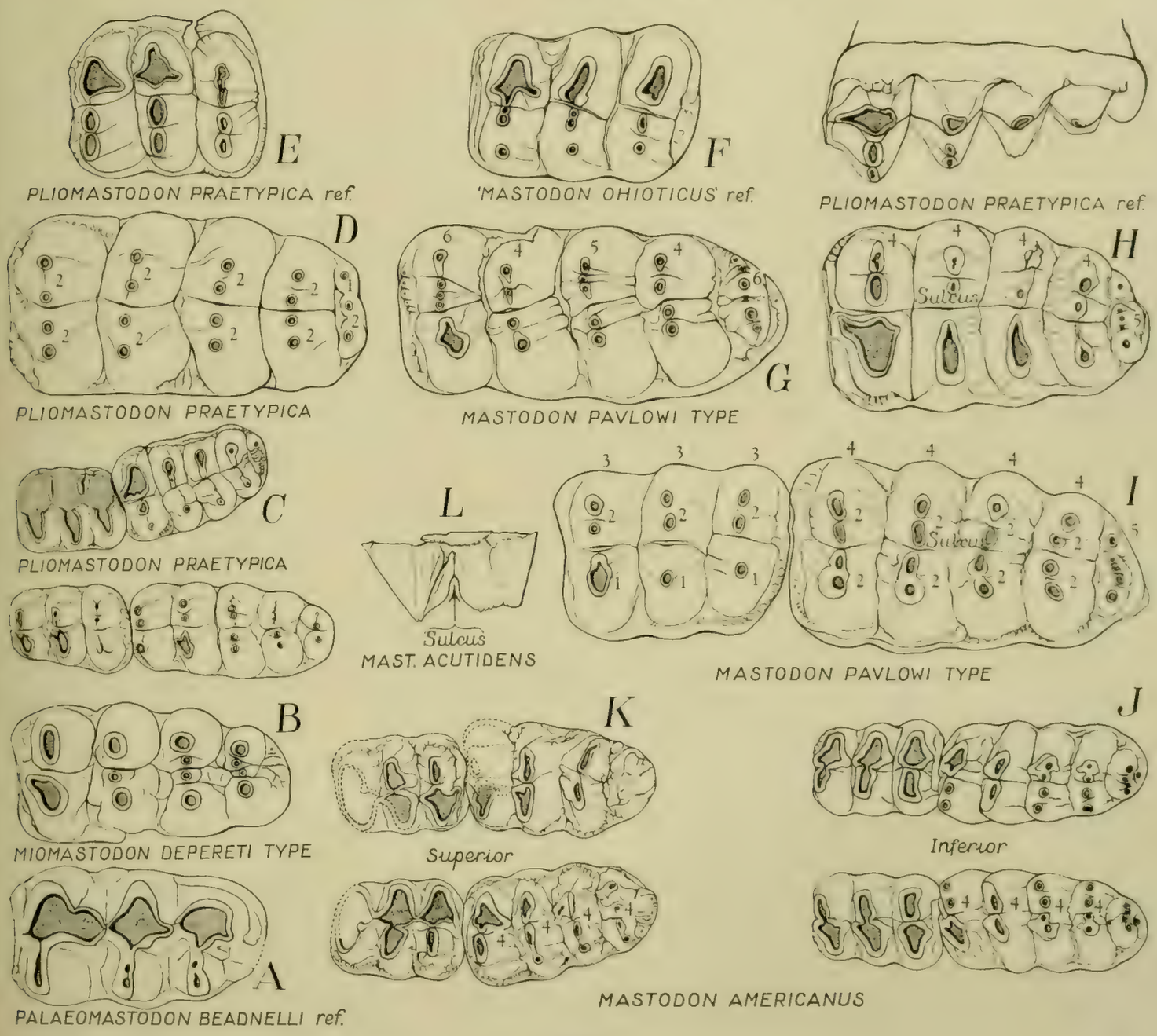


PLATE I

MASTODONTINÆ: PERSISTENT LONGITUDINAL SULCUS, TWO CONES AND FOUR CONELETS IN EACH RIDGE-CREST, RUDIMENTARY ECTO- (INFERIOR) AND ENTOTREFOILS (SUPERIOR). FIGURES LESS THAN ONE-THIRD NATURAL SIZE

Lower Oligocene — A, *Palæomastodon beadnelli* ref., r.M_3. No sulcus. Complete transverse crests and prominent central conules (C, C) prove that *Palæomastodon* is NOT ancestral to *Mastodon*. Amer. Mus. 13481, Fayûm of Egypt (cf. Fig. 187c).

Pleistocene — L, *Mastodon acutidens* sp. nov., l.M^3. Longitudinal sulcus, progressively sharpened ridge-crests. See figures 131 A1–A4 and 135. Amer. Mus. 17727, Rochester, Indiana.

K–J, *Mastodon americanus* ref., r. and l.M^{2-3}, M_{2-3}. Sulcus persistent, 4 conelets, superior entotrefoils (K), inferior ectotrefoils (J) (=*losanges* of Cuvier). See figures 133 and 134. Amer. Mus. 12464, Buffalo, Kansas, and Amer. Mus. 14294, near Fulton, Indiana.

I, G, *Mastodon pavlowi* sp. nov., type, l.M^{2-3}, l.M_3. Primitive. Longitudinal sulcus, 4 conelets, no trefoils. After Pavlow, 1894, Pl. I, figs. 2 and 3, Pestchana, Podolia, Russia.

F, '*Mastodon ohioticus*' ref. [=*M. pavlowi* ref.], r.M_2. Rounded conelets 4–5, entotrefoils. After Pavlow, 1894, Pl. I, fig. 4 (see Fig. 81 of present Memoir), Pestchana, Podolia, Russia.

Pliocene — C, D, E, H, *Pliomastodon praetypica* cotypes and ref. Primitive. Rounded conelets 4, persistent longitudinal sulcus, rudimentary trefoils.

C, D, Cotypes r.M^{2-3}, l.M_{2-3}, after Schlesinger, 1922, Taf. XV, figs. 2 and 4, Szabadka and Batta-Érd, and l.M_3, Taf. XIX, fig. 2, Batta-Érd, Hungary.

E, H, Referred l.M^1 (rev.), after Vacek, 1877, Taf. VI, fig. 3, Neudorf, Austria, and l.M^3, Taf. VI, figs. 1, 1a, near Theresiopel, Hungary.

Lower Miocene — B, *Miomastodon depereti* sp. nov., l.M^3. [Erroneously determined as an l.M_3, Fig. 230, p. 284, of the present Memoir.] The most primitive stage thus far known. Deep longitudinal sulcus, 3–4 conelets, 4 ridge-crests and rudimentary pentaloph. After Mayet, 1908, Pl. VII, fig. 3, Chevilly, Sables de l'Orléanais, France.

COMPARATIVE OBSERVATIONS (1935)

Molars of the true *Mastodon* phylum are readily distinguished: (1) By the persistence of the median sulcus even into the progressive stage (L) of *Mastodon acutidens*; (2) by the persistent *four* conelets; (3) by the rudimentary ectotrefoil and entotrefoil spurs.

ZYGOLOPHODON

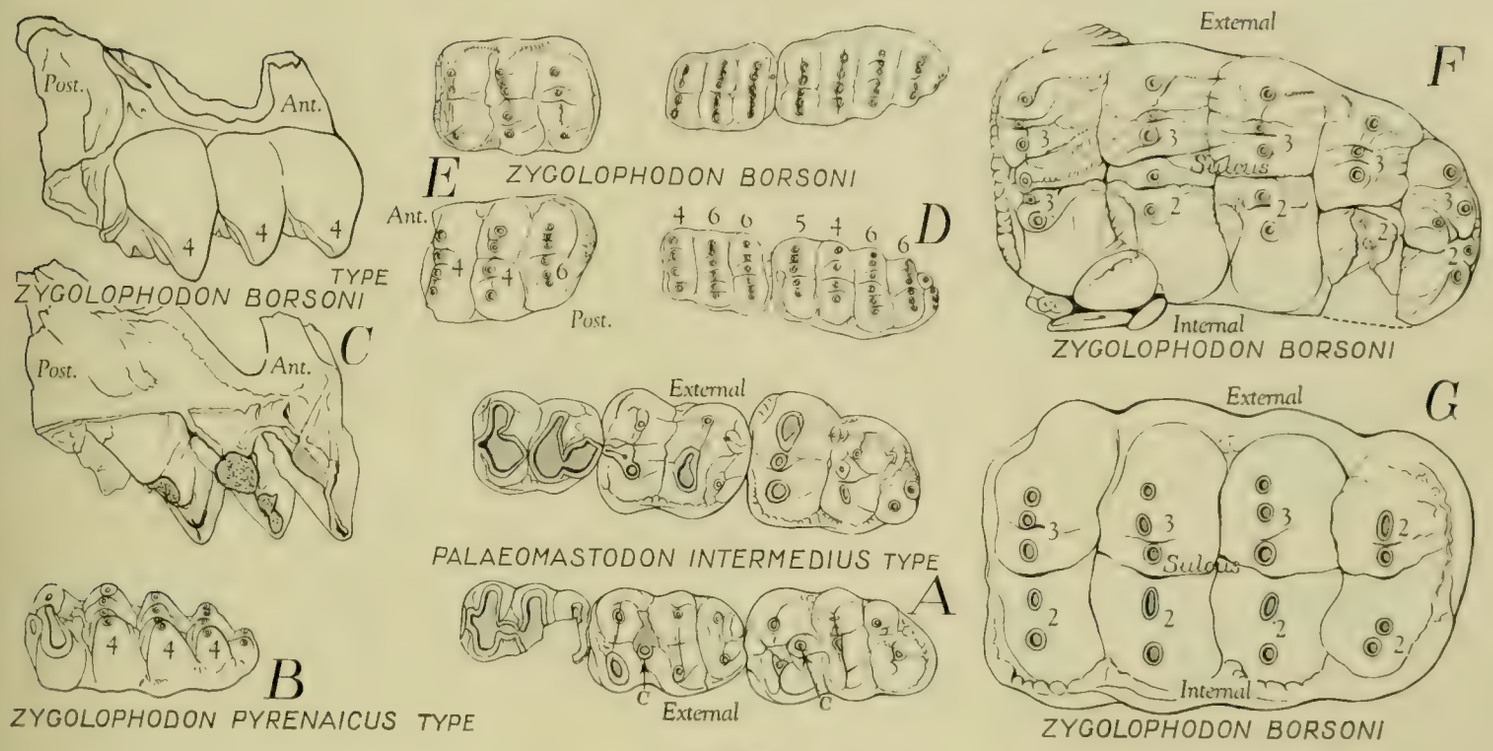


PLATE II

ZYGOLOPHODONTINÆ, ZYGOLOPHODON: PRIMITIVE LONGITUDINAL SULCUS (B, F, G), GRADUALLY DISAPPEARING (E, D), CONELETS 4 (B) PROGRESSIVE TO 6 (D, E, F, G), NO ECTO- OR ENTOTREFOILS. RIDGE-CRESTS OBLIQUELY TRANSVERSE (D). NOT DRAWN TO A UNIFORM SCALE

Lower Oligocene	A, *Palæomastodon intermedius* type and paratype, M_{1-3}, M^{1-3} (see Fig. 92). Longitudinal sulcus blocked by proto- and metaconules. Central conules (C, C) in inferior molars. NOT ancestral to *Mastodon* or *Zygolophodon*.
Middle Miocene	B, *Zygolophodon pyrenaicus* type, r.M_3 (see Fig. 148). Primitive longitudinal sulcus, 4 conelets on three posterior crests.
Middle Pliocene	C, *Zygolophodon borsoni* type, r.M^3 (see Fig. 154). 4–6 conelets on three anterior ridge-crests.
Upper Pliocene	D, *Zygolophodon borsoni* ref., r.M_{2-3}, l.M_{2-3} (see Fig. 150). Progressive 4–5–6 conelets on perfected inferior molar ridge-crests. Vestigial sulcus.
Middle Pliocene	E, *Zygolophodon borsoni* ref., l.M^2, 'intermediate molars' 4–5 conelets. After Schlesinger, 1922, Taf. XIV, fig. 5 (*praetypica*), Rákoskeresztúr, Hungary. M_3, after Schlesinger, 1922, Taf. XV, fig. 5, Bács-Bodrog, Hungary.
Upper Pliocene	F, *Zygolophodon borsoni* ref., l.M^3 (see Fig. 153). Primitive irregular longitudinal sulcus, 5–6 conelets.
	G, *Zygolophodon borsoni* ref., l.M^3 (see Fig. 111). Primitive sulcus, 5 conelets on proto-, meta-, tritolophs, 4 conelets on tetartoloph. After Buffon, 1778, Pl. II.

COMPARATIVE OBSERVATIONS (1935)

Palæomastodon intermedius (A) is distinguished from *Zygolophodon* as follows: (1) Median sulcus lacking; (2) central conules (C, C) present in anterior valleys; (3) entotrefoils sometimes present.

Molars of the relatively rare representatives of the *Zygolophodon* phylum are readily distinguished by the following three outstanding characters:

First, the median sulcus separating the four conelets in *Zygolophodon pyrenaicus* (B) is not very distinct; it is reduced or vestigial in *Z. borsoni* (D–G).

Second, by the subdivision of the *four* transverse conelets of *Zygolophodon pyrenaicus* (B) into five conelets in *Z. borsoni* superior molars (D–G).

Third, by the entire absence of the ecto- and entotrefoil spurs, which are more or less prominent on prolonged usage in specimens of *Pliomastodon* and *Mastodon* (Pl. I, C–K).

TURICIUS

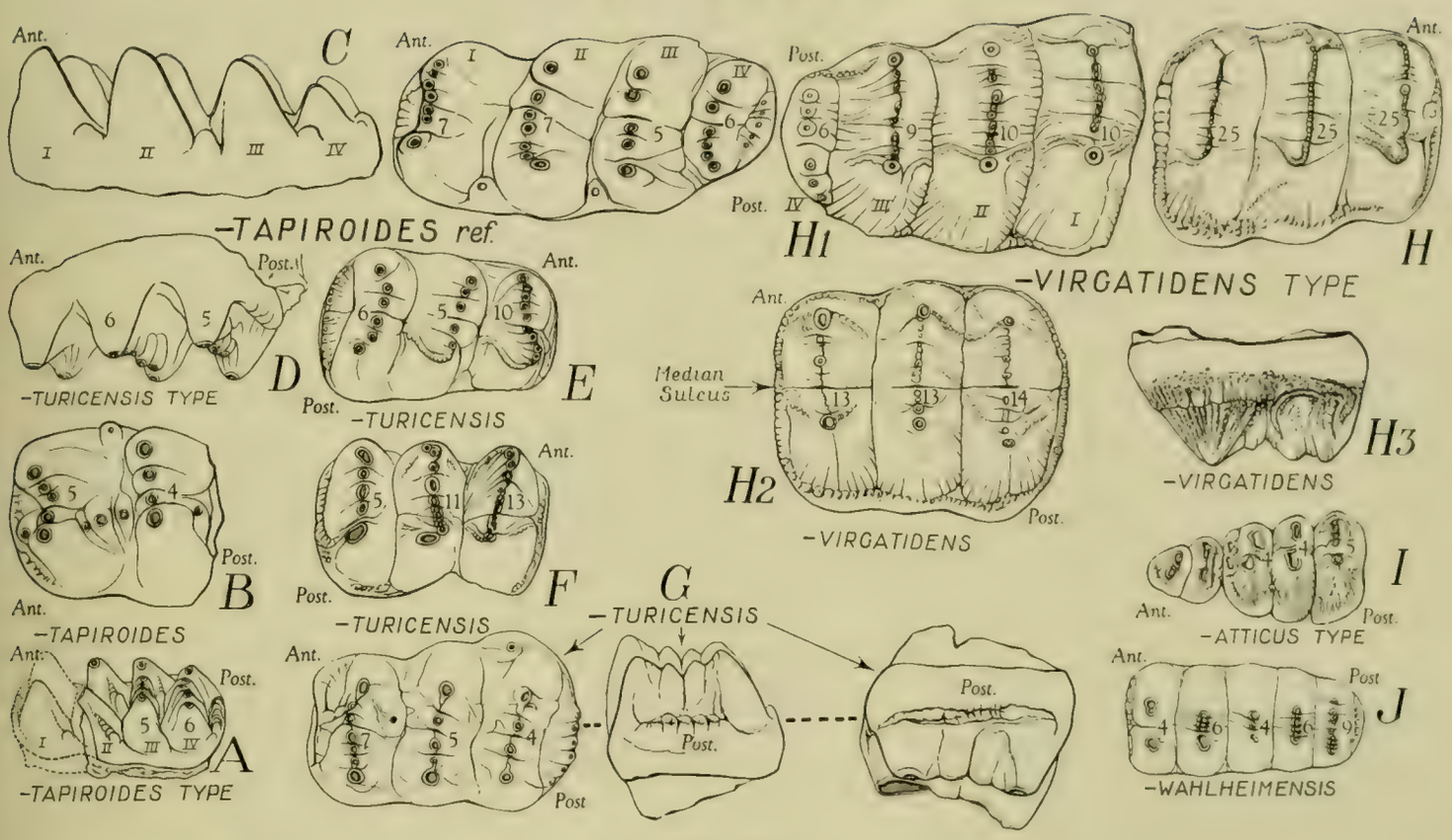


PLATE III

ZYGOLOPHODONTINÆ, TURICIUS: LONGITUDINAL SULCUS (A), VESTIGIAL OR ABSENT (A–J), RIDGE-CRESTS CONSTANT 4 (A–I), 5 (J), RUDIMENTARY ECTO- AND ENTOTREFOIL SPURS (A, F, H), CONELETS 4–5–6 (A, B), RAPIDLY MULTIPLYING, 7 (C)–10 (E)–11–13 (F)–10–25 (H–H3), COMPRESSED AT SUMMIT (J). ALL FIGURES (EXCEPTING I AND J) ABOUT ONE-THIRD NATURAL SIZE

Lower Miocene — A, *Turicius tapiroides* type, r.M_3. Primitive longitudinal sulcus, 4–6 conelets. After Mayet, 1908, fig. 66, Calcaire de Montabusard, France.

B, *Turicius tapiroides* ref., l.M_3. After Mayet, 1908, Pl. VIII, fig. 2, Sables de l'Orléanais du Blésois, Pontlevoy, France.

C, *Turicius tapiroides* ref., r.M_3. Conelets 5–7, ridge-crests 4. After Mayet, 1908, Pl. XI, figs. 4 and 5, Pontlevoy, France.

Upper Miocene — D, *Turicius turicensis* type, l.M^2. After Schinz, 1833, Taf. I, fig. 1, Elgg, Canton Zurich, Switzerland.

E, *Turicius turicensis* homœotype, r.M_2. Conelets 5–10. After von Meyer, 1867, Taf. II, fig. 1, Elgg, Canton Zurich, Switzerland.

F, *Turicius turicensis* ref., r.M_2. Conelets 5–13, trefoil rudiment. After von Meyer, 1867, Taf. II, fig. 2.

G, *Turicius turicensis* ref., r.M_2, r.M^2. Conelets 4–7. After casts of originals in the Munich Museum (1899 IX 1^b = Amer. Mus. 22492, from Freising, Upper Bavaria, and 1891 I 50 = Amer. Mus. 22491, from Moosburg, Bavaria, respectively).

Middle (?) Pliocene — H–H3, *Turicius virgatidens* types, r.M_2 (H), r.M_3 (H 1), l.M^2 (H 2, 3). Conelets 6–25. After von Meyer, 1867, Taf. IV, figs. 1–5, 'Gelben Lehme' bei Fulda, northeast of Frankfort, Germany.

Lower Pliocene — I, *Turicius atticus* type, l.P^4, M^1. Conelets 4–5. After Wagner, 1857, Tab. VII, fig. 16, Pikermi, Greece.

Pliocene — J, *Turicius wahlheimensis* cotype, l.M^3. Conelets compressed, 4–9, 5 ridge-crests. After Klähn, 1922, p. 77, fig. 17, Esselborn, Rheinhessen, Germany.

COMPARATIVE OBSERVATIONS (1935)

Molars of *Turicius* are readily distinguished from those of the *Mastodon* and *Zygolophodon* phyla by the following characters:

First, by the accelerated sharpening and elevation of the transverse crests (A–F).

Second, by the accelerated multiplication of the conelets from six (A) to seven (C) to thirteen (F) to twenty-five (H), thus producing a lofty, sharpened crown parallel with that of *Stegodon*, with minute conelets more numerous than in *Stegolophodon* or primitive species of *Stegodon*.

Third, by the early reduction of the median sulcus, more apparent in Miocene species (A–F), vestigial in Pliocene species (H–H3), absent in specialized *Turicius wahlheimensis* (J).

STEGOLOPHODON

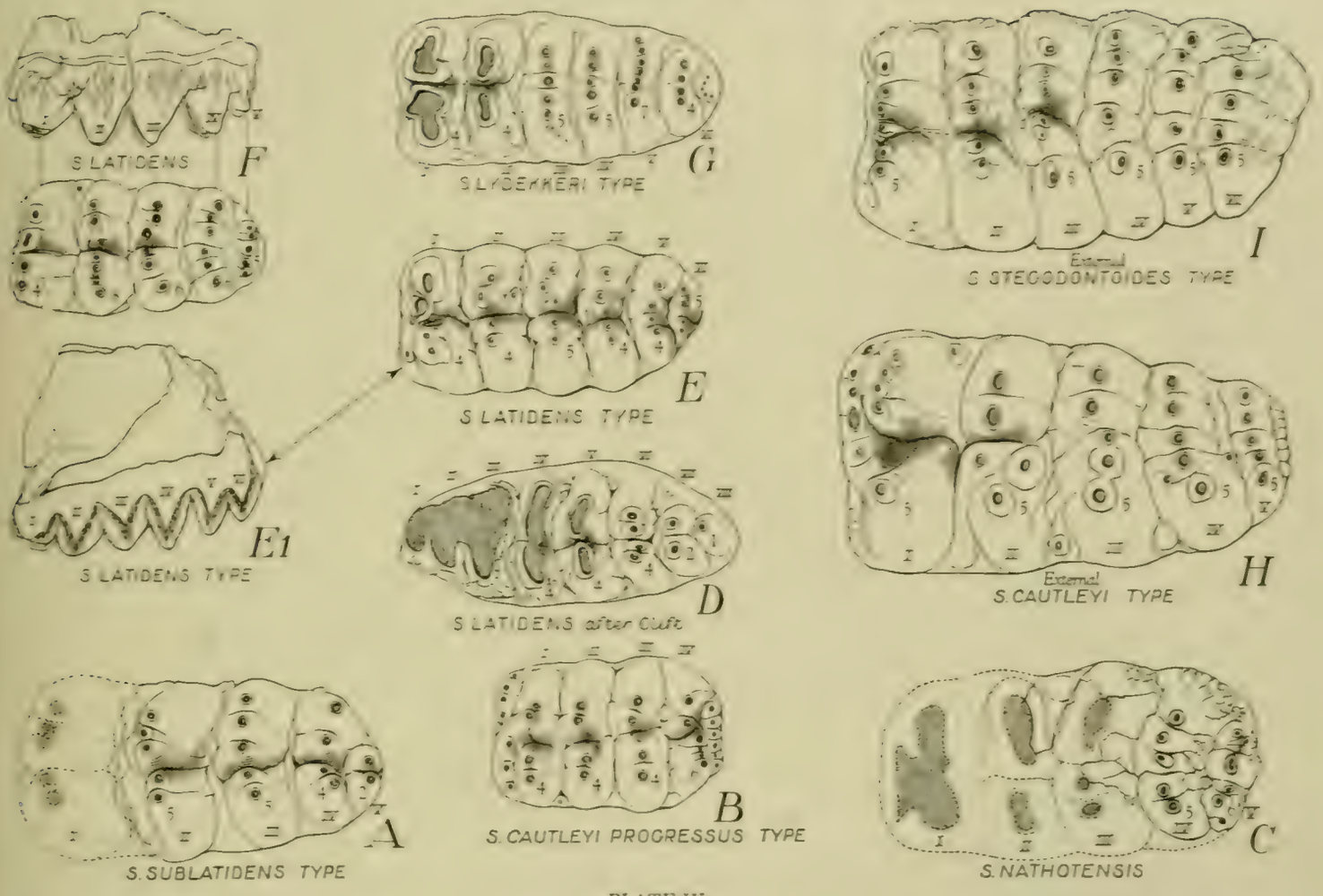


PLATE IV

STEGOLOPHODONTINÆ, STEGOLOPHODON: PRIMITIVE LONGITUDINAL SULCUS, SHADED (A, B), PERSISTING IN I–IV ANTERIOR RIDGE-CRESTS (E, E1), IN I–III ANTERIOR RIDGE-CRESTS (F), VESTIGIAL IN RIDGE-CRESTS I–III (G, H, I). CONELETS ROUNDED, INCREASING FROM 4–5 (A, D), 5–7 (C, H, I, G). POSTERIOR RIDGE-CRESTS IV–VI PROGRESSIVE, WITH CONELETS 5–7 (G), CONELETS NOT EXCEEDING 5 (H, I)

Mio-Pliocene — B, *Stegolophodon cautleyi progressus* type, r.M^1. Amer. Mus. 19446, near Chinji Bungalow, India. Summit of Lower Chinji horizon, 2,000 feet above base of Lower Siwaliks.

C, *Stegolophodon nathotensis* type, r.M_2. Conelets 5–6. Amer. Mus. 19455, near Nathot, Lower Middle Siwaliks, India. Lower Chinji horizon.

Lower Pliocene — D, *Stegolophodon latidens* type, r.M_3. Ridge-crests I–VII, conelets 4, sulcus on ridge-crests I–IV. After Clift, 1828, Pl. XXXVIII, fig. 1, near Yenangyaung, Burma. Lowest levels of Irrawaddy Series (fluviatile).

E, *Stegolophodon latidens* type, r.M^3. Ridge-crests I–VI, sulcus on ridge-crests I–IV. E 1 (section), ridge-crests coalescent at base (I–III). After cast (Amer. Mus. 21978) of Clift's type, 1828, Pl. XXXVII, fig. 1, near Yenangyaung, Burma, lowest levels of Irrawaddy Series (fluviatile).

F, *Stegolophodon latidens* ref., r.M^1. Sulcus on ridge-crests I–III, conelets 4–6, ridge-crests $4\frac{1}{2}$. After Matsumoto, 1926.1, Pl. v, figs. 1 and 3 (*Prostegodon*), Shiwogama, Miyagi District, Province of Rikuzen, Japan.

Pliocene (?) — G, *Stegolophodon lydekkeri* sp. nov., l.M^3. Ridge-crests I–VI, conelets 4–7, sulcus on ridge-crests I and II only. After Lydekker, 1886.2, fig. 19 (as *M. latidens*), Borneo.

Middle(?) Pliocene A, *Stegolophodon sublatidens* type, r.M^3. Conelets 4–5. After Schlesinger, 1917, Taf. XVII, fig. 2, Teschen (Schlesien), Austria.

Middle Pliocene H, *Stegolophodon cautleyi* type, r.M^3. Ridge-crests I–V, sulcus on ridge-crests I and II, conelets 5. After Lydekker, 1886.1, p. xv, fig. 6, Perim Island, India.

Upper(?) Pliocene I, *Stegolophodon stegodontoides* Pilgrim, type, r.M^3. Ridge-crests I–VI, sulcus on ridge-crests I–III, conelets 5. After Lydekker, 1880, Pl. XXXIX, Lehri, Punjab, India, possibly Upper Siwaliks.

COMPARATIVE OBSERVATIONS (1935)

Molars of *Stegolophodon* are readily distinguished from those of the *Mastodon*, *Zygolophodon*, and *Turicius* phyla by the following characters:

First, by the persistence of the *median sulcus* separating the inner and outer pairs of cones of all the crests (A, B, D), of the three to four anterior crests (E, F, I), of the two anterior crests (G, H).

Second, by the rounded, bunoid conelets separated by median sulcus (A–H).

Third, by the closure of the enamel in the base of the transverse valleys, as seen in section (E1), very characteristic of *Stegodon*.

The second and third of the *Stegolophodon* characters enumerated below link this genus with the genus *Stegodon*. But we must remember that *Stegolophodon cautleyi* is of Middle Pliocene age (Perim Island), contemporary with the true Middle Pliocene *Stegodon bombifrons* (Dhok Pathan). See Volume II, Chapter XV, Stegodontoidea.

True Mastodon americanus Type in Eurasia.—It is interesting to note that in addition to the lophodont and zygolophodont forms related to *Mastodon borsoni* and *M. turicensis*, described by Pavlow and beautifully figured by her (1894), there also occurs in several localities, e.g., Pestchana and Krasnoïe, Podolia, Russia, the molar type which she rightly compares closely with that of *M. ohioticus*, i.e., *M. americanus* (see Fig. 81 of the present Memoir). Of these Russian specimens Marie Pavlow (1901, p. 12) speaks as follows:

> Je veux profiter de l'occasion, puisque je parle des mastodontes, pour compléter la description des restes fossiles du *Mastodon Ohioticus*, trouvé à Pestchana en 1892, et décrit par moi en 1894 (*l. cit.*). En parlant de la partie antérieure de la mandibule de cet animal, je me suis bornée à dire (p. 10), qu'on ne trouve sur ce morceau de mandibule aucune trace d'alvéole pour la défense. Cela me semblait suffisant pour faire croire, que cet animal adulte n'avait pas de défenses inférieures et qu'il pourrait être rapporté par ce caractère au *Mast. Ohioticus*, les autres caractères de dents venant appuyer cette détermination. Mais ayant rencontré dans la littérature quelques objections à ce sujet, je me crois obligée de donner une description plus détaillée de cette partie de mandibule, en l'accompagnant d'un dessin (Pl. 1, fig. 3).

This description, with photographic figures (1894, Pl. 1, figs. 2 and 3), convinces us that we have from Pestchana a form closely resembling *Mastodon americanus* but which may not be specifically identical[1]; the Pestchana specimens are certainly closer to *M. americanus* than to *Zygolophodon borsoni*.

The fact that this recent review by Pavlow of the Eurasiatic Proboscidea yields examples of only four individual specimens of *Mastodon americanus* from two localities, Pestchana and Krasnoïe, as compared with the relative abundance of *Zygolophodon borsoni*, is another proof of the great scarcity of members of the true *Mastodon americanus* phylum up to the period of its abundant revelation in the eastern forests of North America. As shown in Pl. 1, pp. 134–135, other specimens referred by Vacek to *Zygolophodon* prove to belong to *Mastodon*.

4. RÉSUMÉ OF DISCOVERY AND DESCRIPTION OF THE MASTODONTINÆ

The earliest discoveries of the American Mastodon on the Hudson River in 1705, and those in Kentucky near the Ohio River in 1739, antedated by thirty years the dissemination of the various editions of the "Systema Naturæ" (1735–1766) of Linnæus. From 1752 to 1778 Buffon described the "os d'éléphans," as cited in full below, of this Kentucky animal without assigning to them a specific name; subsequently Kerr's description of *Elephas americanus* appeared (1792). Nevertheless these fossils attracted little attention, in fact, even as late as 1797 Blumenbach affixed the clumsy name *Ohio-Incognitum* to one of the fossil teeth found on the Ohio River, and as late as 1806 Cuvier named the same animal *Le Grand Mastodonte* and *Mastodonte de l'Ohio*.

Consequently the history of proper nomenclature lags far behind the history of discovery, and the very last stage in the long progress of palæontology is the ancestral history or phylogeny.

Type Locality, Big-Bone Lick, Ky.—The type locality of the first discoveries of *Mastodon* in America is certainly the Big-bone-swamp (*fide* Kerr, 1792, p. 116), subsequently known as the 'Big-Bone Lick,' a few miles southeast of the Ohio River, in Kentucky. Thus the animal took its second name *Ohio-Incognitum* Blumenbach, 1797, from the Ohio River, and became known as *Mammut ohioticum* Blumenbach in 1799, *Mastodonte de l'Ohio* Cuvier in 1806.

Chronologic notes respecting early explorers of Big-Bone Lick were published by William Cooper in 1831 [Monthly American Journal of Geology and Natural Science, Vol. I, 1831, p. 159]. This list contains the statement that a French officer named Longueil secured fossil bones from a morass near the Ohio River in 1739, and that they were collected by some Indians and not by a Frenchman. The list goes on to say that Col. George Croghan visited Big-Bone Lick in 1765.

[1](1935) Made the type of *Mastodon pavlowi* (see Appendix).

Cuvier, 1806.2, p. 280, in part, and 1834, Vol. II, p. 266.—Le plus célèbre de ces dépôts, celui qu'ont visité Longueil, Croghan et tant d'autres, celui qui a fait donner au mastodonte le nom d'animal de l'Ohio, porte lui-même celui de *Big-Bone-Strick* ou *Great-Bone-Lick*. Il est dans l'état de Kentucky, à la gauche et au sud-est de l'Ohio, à quatre milles du fleuve, trente-six milles au-dessus de l'embouchure de la rivière de Kentucky [Footnote: 'Volney, Tableau du climat et du sol des États-Unis d'Amérique, I, page 100.'], presque vis-à-vis celle de la rivière dite la Grande Miamis. C'est un lieu enfoncé entre des collines, occupé par un marais qu'entretient un filet d'eau salée, et dont le fond est d'une vase noire et puante. Les os se trouvent dans la vase et dans les bords du marais, au plus à quatre pieds de profondeur, suivant le rapport que nous en a fait feu le général Collaud, qui avait été sur les lieux, et qui, en fouillant pendant trois jours seulement, avait recueilli vingt-quatre morceaux. Leur abondance y est étonnante. Déjà Croghan croyait y avoir vu des restes de plus de trente individus; mais on en a recueilli depuis un bien plus grand nombre.

Genotype Locality: Big-Bone Lick, Kentucky

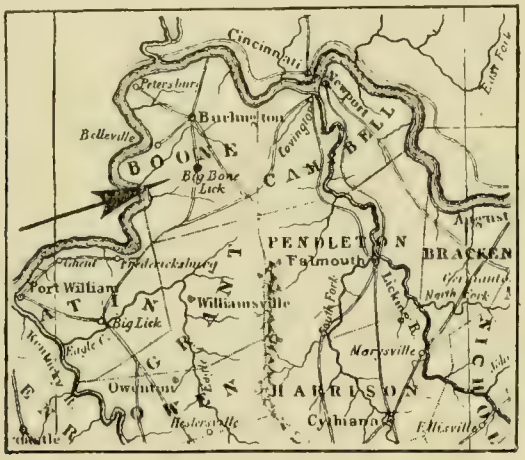


Fig. 85. Big-Bone Lick, Boone County, Kentucky, from map in Anthony Finley's "A new American atlas," etc., folio, Philadelphia, 1826, No. 10 (*fide* P. Lee Phillips, "A List of Maps of America in the Library of Congress," 1901, p. 838).

This map is of great historic interest as showing one of the birthplaces of vertebrate palæontology in America. Visited by the French officer Longueil, mentioned and also fully described by Buffon, Blumenbach, and especially Cuvier, founder of vertebrate palæontology. The Mastodon in the New World took the part played by the Mammoth in the Old World, in fact, it is remarkable that *Elephas americanus* Kerr (1792) anticipates *Elephas primigenius* Blumenbach (1799).

In the following generic list only the chief specific names applied to the American Mastodon are included; a full list of this polynomial species is given below under the heading "*Mastodon americanus*" (p. 165).

CHRONOLOGIC ORDER OF DISCOVERY AND PRELIMINARY DESCRIPTION

See Figure 86

			Original Name	Specific Reference in Present Memoir
	1705	New York	First mention of fossil remains near Albany, New York.	
	1714		First published account of two teeth and a thigh bone found thirty miles south of Albany, New York, on the Hudson River.	
	1739	Big-Bone Lick, Ohio River	First fossil remains found by Indians in the Big-Bone Lick, Ky., near the Ohio River, and given to a French officer by the name of Longueil; subsequently mentioned by Buffon, Blumenbach, and Cuvier.	
	1778	" "	A single molar tooth from the Ohio River figured by Buffon (Fig. 84 B).	
1.	1792	" "	*Elephas americanus* Kerr	= *Mastodon americanus*
2.	1797	" "	*Ohio-Incognitum* Blumenbach	= " "
2.	1799	" "	*Mammut ohioticum* Blumenbach	= " "
3.	1803	" "	*Elephas macrocephalus* A. Camper	= " "
4.	1806	" "	*Le Grand Mastodonte* Cuvier	= " "
4.	1806	" "	*Mastodonte de l'Ohio* Cuvier	= " "
5.	1808 (?)	" "	*Harpagmotherium canadense* Fischer de Waldheim (cf. Sherborn, 1924, p. 1022, "*Harpagonotherium canadense*, Anim. foss. Siberie.")	= " "
5a.	1814	No. America	*Mastodon Macrodon* Rafinesque	= " "

CHRONOLOGIC ORDER OF DISCOVERY AND PRELIMINARY DESCRIPTION (*Continued*)

			Original Name	Specific Reference in Present Memoir
6.	1814	Ohio River	*Mastotherium megalodon* Fischer de Waldheim	= *Mastodon americanus*
4.	1817	" "	*Mastodon giganteum* Cuvier	= " "
4.	1824	" "	*Mastodon maximus* Cuvier	= " "
7.	1854	Canada	*Elephas Rupertianus* Richardson, Swan River, Lake Winnipeg basin, Canada	= *Mastodon americanus rupertianus*
	[1835	Russia	*Mastodon podolicum* Eichwald	= *Deinotherium podolicum* (see Chap. IV, p. 85)]
4.	1868	Ohio River	*Mastodon americanus* Kerr [Leidy]. First use of Kerr's specific name in America	= *Mastodon americanus*
8.	1890	S. Carolina	*Mastodon rugosidens* Leidy, Beaufort County	= *Mastodon americanus rugosidens*
9.	1894	Russia	*Mastodon ohioticus* ref., Pavlow, Podolia	= *Mastodon* sp. (?). See No. 26 below
10.	1901	Fayûm	*Palæomastodon Beadnelli* Andrews, Egypt	= *Palæomastodon beadnelli*[1]
11.	1905	"	*Palæomastodon parvus* Andrews, Egypt	= *Palæomastodon parvus*[1]
12.	1914	Iowa	*Mammut progenium* Hay, Harrison County	= *Mastodon progenius*
13.	1919	Hungary	*Mastodon (Mammut) americanus* Penn. *forma praetypica* Schlesinger	= *Pliomastodon americanus praetypica*
14.	1921	Nebraska	*Mastodon matthewi* Osborn, Sioux County	= *Pliomastodon matthewi*
15.	1921	Nevada	*Mastodon merriami* Osborn, Thousand Creek, Humboldt Co.	= *Miomastodon merriami*
16.	1921	Hungary	*Mastodon tapiroides americanus* (Schlesinger in Osborn)	= *Miomastodon tapiroides americanus*
17.	1922	Fayûm	*Palæomastodon intermedius* Matsumoto, Egypt	= *Palæomastodon intermedius*[1]
18.	1926	Illinois	*Mastodon americanus plicatus* Osborn, Walnut	= *Mastodon americanus plicatus*
19.	1926	Oregon	*Mammut oregonense* Hay, Baker County	= *Mastodon oregonensis*
20.	1930	Florida	*Pliomastodon sellardsi* Simpson, Brewster	= *Pliomastodon sellardsi*
21.	1930	California	*Pliomastodon vexillarius* Matthew, Fresno County	= *Pliomastodon vexillarius*
22.	1931	Nebraska	*Mastodon moodiei* Barbour. Milford	= *Mastodon moodiei*
23.	1933	New Mexico	*Mastodon raki* Frick, Hot Springs	= *Mastodon raki*
24.	1933	Alaska	*Mastodon americanus alaskensis* Frick, near Fairbanks	= *Mastodon americanus alaskensis*
24a.	1934	Nebraska	*Mastodon grangeri* Barbour, near Pender, Thurston Co.	= *Mastodon grangeri*
25.	1935	France	*Miomastodon depereti* sp. nov.,[2] Chevilly	= *Miomastodon depereti* sp. nov.
26.	1935	Russia	*Mastodon pavlowi* sp. nov.,[2] Pestchana	= *Mastodon pavlowi* sp. nov.
27.	1935	Indiana	*Mastodon acutidens* sp. nov.,[2] Rochester	= *Mastodon acutidens* sp. nov.

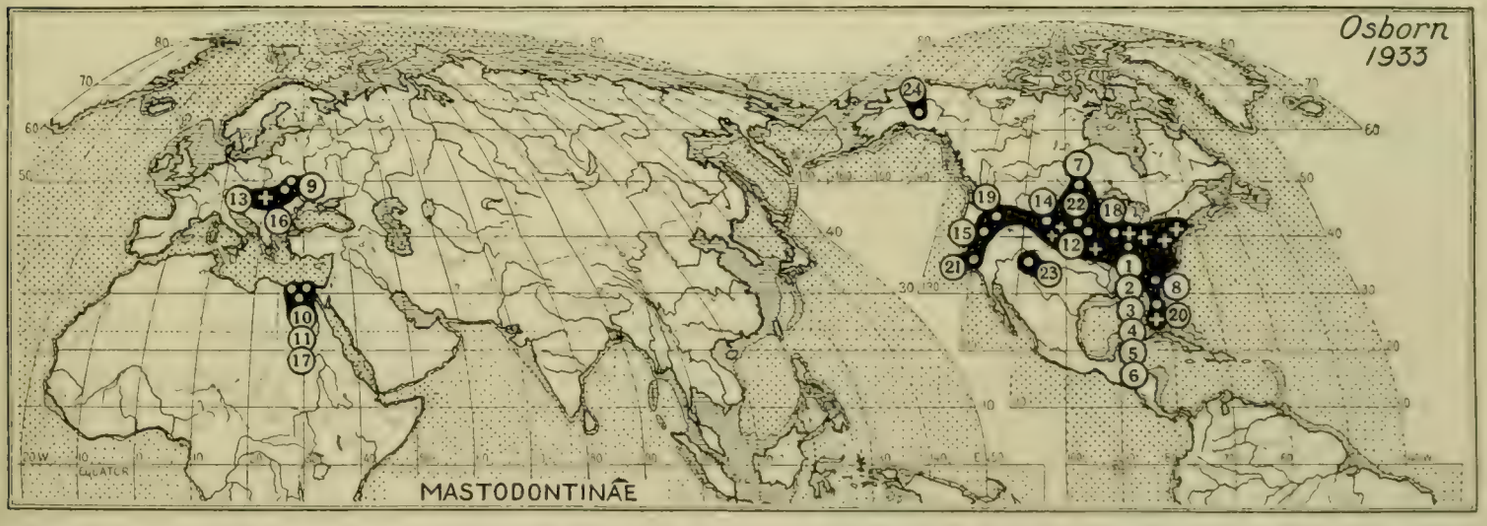


Fig. 86. Geographic distribution (according to the numbers in the list above) of the principal species of the Mastodontinae. The white dots within the black areas represent the approximate localities where the types were discovered. The white crosses represent referred specimens. Nos. 24a and 27 omitted on this map. Nos. 25 and 26 are omitted here but appear on map (Fig. 123a). See also geographic distribution map forming the inside cover, or front end-paper, of the present Volume.

The above list of genera and species shows that there are many gaps in this great Mastodontinæ phylum to be filled by future discovery; also that while the Pleistocene *Mastodon* stage is well known, the Pliocene and Miocene stages of *Pliomastodon* and *Miomastodon* are known only from a few grinding teeth and tusks. The Oligocene stage, *Palæomastodon*, is still very imperfectly known.[1]

[1]See pages 143–149 below, also Palæomastodontinæ in Appendix at close of the present Volume.

[2]See Appendix at close of the present Volume for description of *Miomastodon depereti* sp. nov., of *Mastodon pavlowi* sp. nov., and of *Mastodon acutidens* sp. nov.

5. PROGRESSIVE CHARACTERS AND GENERIC DISTINCTIONS OF THE MASTODONTINÆ

Generic and Specific Succession.—As explained in the preceding section, the inclusion of the Lower Oligocene genus *Palæomastodon*[1] as a form related to the phylum Mastodontinæ is provisional and depends upon our further knowledge of this relatively rare animal. While we are certain that the true *Palæomastodon* possesses a longer jaw but a broader and shorter skull than its Lower Oligocene contemporary *Phiomia*, while the superior grinding teeth are comparatively short and broad, and while in the crowns of the superior and inferior grinding teeth the proto- and metaconules forbid the ancestral relationship of *Palæomastodon* to *Pliomastodon*, *Miomastodon*, and *Mastodon*, we must await further knowledge of the cranium and of the cutting teeth, also of the incisors of *Palæomastodon*, before we can form a positive opinion on this very important and interesting question.

Meanwhile we may contrast the characters of these four genera so far as they are known:

Lower Oligocene of North Africa	Miocene and Pliocene (?) of Europe and of North America	Pleistocene of Eurasia and of North America
Palæomastodon Andrews, 1901	*Miomastodon*, *Pliomastodon* Osborn, 1922, 1926	*Mastodon* Cuvier, 1817
Palate and grinding teeth relatively short and broad.	Palate and grinding teeth somewhat elongated.	Palate and grinding teeth relatively elongated.
Dental formula: $I\frac{0}{0}-\frac{2}{2}-\frac{0}{0}$ $Dp\frac{?}{?}$ $P\frac{2}{2}-\frac{4}{4}$ $M\frac{1}{1}-\frac{3}{3}$.	Dental formula: $I\frac{0}{0}-\frac{2}{2}-\frac{0}{0}$ $Dp\frac{?}{?}$ $P\frac{?}{?}$ $M\frac{0}{0}-\frac{0}{0}-\frac{3}{3}$.	Dental formula: $I\frac{0}{0}-\frac{2}{2}-\frac{0}{0}$ $Dp\frac{2}{2}-\frac{4}{4}$ $P\frac{0}{0}-\frac{0}{0}-\frac{4}{4}$ (vestigial) $M\frac{1}{1}-\frac{3}{3}$.
Ridge formula: $P\,2\frac{1}{0}$ $P\,3\frac{1}{1}\frac{1/4}{1/4}$ $P\,4\frac{2}{2}$ $M\,1\frac{2}{3}\frac{1/2}{1/2}$ $M\,2\frac{2}{3}\frac{1/2}{1/2}$ $M\,3\frac{2}{3}\frac{1/2}{1/2}$.	Ridge formula: Probably $P\,4\frac{3}{3}$ $M\,1\frac{3}{3}$ $M\,2\frac{3}{3}$ $M\,3\,{}_{?4}\frac{4}{1/3-5}$.	Ridge formula: $Dp\,2\frac{2}{2}$ $Dp\,3\frac{2}{2}$ $Dp\,4\frac{3}{3}$ $M\,1\frac{3}{3}$ $M\,2\frac{3}{3}$ $M\,3\,{}_{4}\frac{4\ +}{3/4-5}$.
Grinding teeth brachyodont, bunolophodont, with proto- and metaconules (see Fig. 93). No median sulcus.	Grinding teeth with more elevated lophs. A median sulcus; no conules.	Grinding teeth subhypsodont. A median sulcus; no conules.
Rudimentary third crests in 'intermediate molars,' P 2-M 1.	Fully formed third crests in 'intermediate molars.'	Third crests fully formed in 'intermediate molars.'
Lower jaw and symphysis greatly elongated.	Lower jaw and symphysis moderately elongated.	Lower jaw and symphysis abbreviated.
Incisive tusks oval in section, with broad enamel band.	Incisive tusks rounded, with enamel band (*Miomastodon*); without enamel band (*Pliomastodon*).	Incisive tusks rounded, without enamel band.
Palæomastodon parvus.	*Pliomastodon matthewi.*	*Mastodon americanus.*
Palæomastodon intermedius.	*Pliomastodon americanus praetypica.*	*Mastodon americanus rugosidens.*
Palæomastodon beadnelli.	*Miomastodon tapiroides americanus.*	*Mastodon americanus plicatus.*
	Miomastodon merriami.	*Mastodon progenius.*

Dental Succession.—The relations of the deciduous premolars, $Dp^3(?)$, $Dp_3(?)$, of *Palæomastodon* in distinction from the permanent premolars, P^3, $P_2(?)$, have not been observed. Nor do we know the relations of the deciduous premolars to the permanent premolars in *Miomastodon* or in *Pliomastodon*.

According to the observations of Hays (1834) and of Warren (1852, 1855) cited below, the true Pleistocene *Mastodon americanus* agrees with Pleistocene and recent species of the Elephantidæ in the *suppression of the permanent premolar teeth;* the fourth true superior and inferior premolars, P^4-P_4, form in the jaw but they do not erupt. In *Elephas* the corresponding permanent teeth, P^4-P_4, are suppressed entirely.

[1]See pages 143–149 below, also Palæomastodontinæ in Appendix.

PRINCIPLES OF GRINDING TEETH EVOLUTION, PLATES I, II, III, AND IV

The succession and relationship of members of the true Mastodontinæ phylum depend upon our very close examination and comparison of the structure of the grinding teeth, as displayed in the accompanying comparative figures. As first observed by Lartet, the grinding teeth of the true *Mastodon americanus* are fundamentally different from those of *Mastodon borsoni* which Vacek has rightly referred to *Zygolophodon*.

Median Sulcus.—In the carefully drawn Plates I, II, III, and IV, illustrating the evolution of the grinding teeth in *Mastodon*, *Zygolophodon*, *Turicius*, and *Stegolophodon*, a median longitudinal sulcus separates the external and internal cones both in the superior and inferior molars. This demonstrates that the ancestral proboscidean molar was *tetrabunodont*, as in *Mœritherium*, not hexabunodont, as in *Palæomastodon*.

Ridge Formulæ.—In the carefully drawn figures of the superior and inferior grinders of *Palæomastodon* the construction of the ridge-crests of the grinding teeth should be examined with great care, because it is difficult to express the rudimentary condition of the third crest or *tritoloph* in a formula. It will be seen (Figs. 90B, 91, 92, 93, 94, 95) that the *tritoloph and tritolophid are in a formative stage;* the tritoloph is rudimentary even in M^3 (Fig. 94D); it consists of a single cone in M^1, M^2 (Fig. 91); the *tritolophid* is completely formed in M_1 (Fig. 92B); it is less fully formed in M_2 (Fig. 92B). Consequently *Palæomastodon* is far more primitive than *Mastodon* in the formation of the tritoloph and tritolophid, yet it exhibits the ancestral stages in the development of this third crest so characteristic of all the Proboscidea.

By close comparison of all the figures of the upper and lower grinding teeth of *Palæomastodon*, *Miomastodon*, *Pliomastodon*, and *Mastodon*, it is observed:

(1) That the molar crowns in *Palæomastodon* are mainly tetrabunodont, i.e., each protoloph (superior) and each protolophid (inferior) is composed of a main external bunoid cone and a main internal bunoid cone; in the superior molars (Fig. 94D) where the conules persist the main crown is hexabunodont. The presence of proto- and metaconules blocking the median sulcus forbids the ancestry of *Palæomastodon* to *Mastodon*.

(2) The vestigial intermediate protoconules and metaconules are observed in the hexabunodont superior molars of *Palæomastodon intermedius*, thus the crested upper grinders are hexabunodont or six coned, whereas the lower grinders are subtrilophodont (Fig. 93, M^3-M_3, Fig. 94). This primitive condition of the *cones* connects *Palæomastodon* with its undiscovered sexitubercular-quadritubercular ungulate ancestors; the *conules* observed in the third superior molar, M^3, of *P. intermedius* (Figs. 93 and 89) are not seen in M^2 of the same species (Fig. 92); the conules are vestigial or disappearing structures.

(3) The protoconules and metaconules of *Palæomastodon* (Fig. 93) obstruct the sulcus of *Mastodon*. In advanced stages of *Palæomastodon* and of *Miomastodon* the superior grinders, like the inferior, become trilophodont.

(4) To the protoloph and -lophid also metaloph and -lophid the superior and inferior grinders, $M^{1\text{-}3}$-$M_{1\text{-}3}$ add a rudimentary tritoloph and -lophid or third superior and inferior transverse ridge-crest (Figs. 92 and 94). The genesis of the tritoloph and -lophid is very clearly shown in *Palæomastodon intermedius* (Fig. 92); this trilophodont structure in all the superior and inferior true molars becomes a *distinctive character of the grinding teeth in all the Proboscidea*, except *Deinotherium* in which Dp 4 and M_1 are trilophodont (Figs. 54, 60, 71); consequently it is an *ordinal* character.

(5) In *Palæomastodon* the fourth superior and inferior premolars exhibit the protoloph and -lophid and metaloph and -lophid only, i.e., no tritoloph and -lophid, like the fourth superior premolar of *Phiomia* (Fig. 179).

The fourth deciduous premolars of *Phiomia*, Dp^4-Dp_4, also acquire a tritoloph and -lophid. The fourth deciduous premolars of *Miomastodon* and *Pliomastodon* are not known. The fourth deciduous premolars of *Mastodon americanus* have a fully developed tritoloph and -lophid (see Warren, 1852, p. 213, Pl. v). Consequently a trilophodont fourth deciduous premolar appears to be a progressive *ordinal* character of the Proboscidea.

(6) Thus the third lophs, tritoloph and tritolophid, are successively established in M^3-M_3, in M^2-M_2, in M^1-M_1, and in P^4-P_4 by the addition of a third crest.

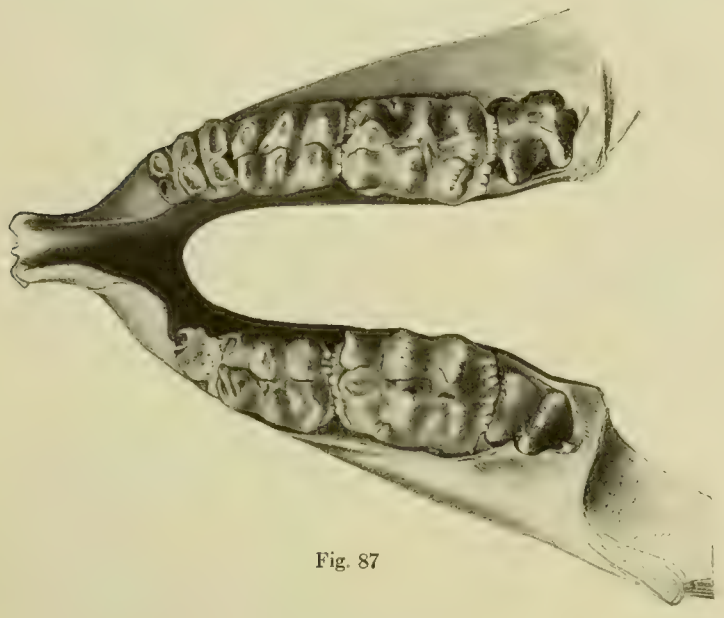


Fig. 87

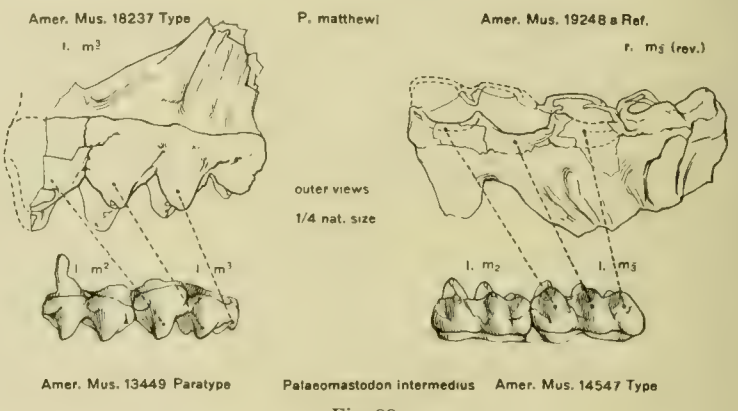


Fig. 88

Fig. 87. Crown view of inferior dentition and jaw of *Mastodon americanus*, containing Dp_4, M_1, M_2, and M_3 anterior lophs. After Warren, 1852, Pl. v, one-sixth natural size. Compare figures 150 and 151 of *Zygolophodon borsoni*.

Fig. 88. Comparison of third inferior and superior grinding teeth of *Pliomastodon matthewi* (upper) and *Palæomastodon intermedius* (lower), one-fourth natural size.

(7) The main internal and external bunoid cones in the Mastodontinæ phylum, namely, in *Miomastodon*, *Pliomastodon*, and *Mastodon*, remain separate, they never unite transversely into a completed ridge-crest; thus all the Mastodontinæ remain bunolophodont, they never become fully zygolophodont.

(8) The passage from extreme brachyodonty to subhypsodonty is observed as follows: (*a*) In *Palæomastodon* the paired cones or lophs are extremely brachyodont; (*b*) the cones or lophs in the three successive stages of elevation are seen in the ascending species of *Miomastodon merriami*, *Pliomastodon matthewi*, *Miomastodon tapiroides americanus*, and *Pliomastodon americanus praetypica*, as described in the *Miomastodon* section; (*c*) the summits of the cones are converted into sharply acute ridge-crests, as observed in the unworn grinders of *Mastodon acutidens* (Fig. 135 and Pl. I, L).

(9) Observe wide differences between *Palæomastodon* and *Phiomia* in conules and trefoils: (a) In *Palæomastodon* the *central conule* (Fig. 90) is arrested, proto- and metaconules close the sulcus (Fig. 93); (b) in *Phiomia* the *central conules* progress strongly (Fig. 90); in the inferior molars of (c) *Miomastodon* and *Pliomastodon* the *ectoconelets* expand into trefoil spurs (Fig. 89); in (d) *Mastodon americanus* rudimentary trefoil spurs are observed on ectoconelets below and entoconelets above, the mesoconelets being reduced.

Summing up, the progressive 'Mastodontinæ' characters are as follows: (1) Early loss of the *conules;* (2) very gradual development of the *tritoloph;* (3) relatively rapid development of the *tritolophid;* (4) persistent separation by a sulcus of the *internal cones* from the *external cones*, hence bilobed; (5) early development of the internal cingulum on the superior molars, retarded development of the external cingulum on the inferior molars.

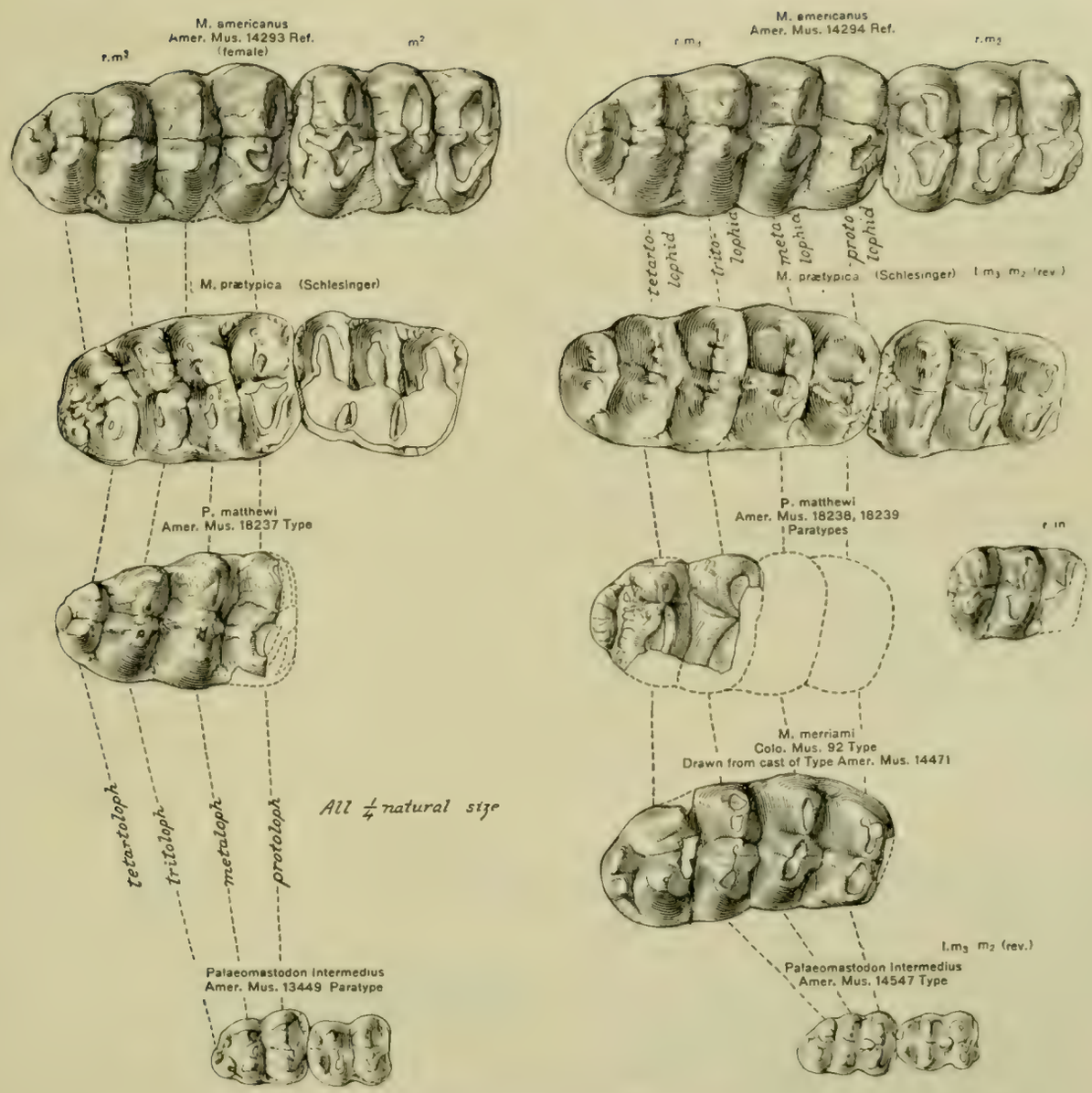


Fig. 89. Evolution of the Molar Ridge-crests in the Mastodonts, Oligocene to Pleistocene

Compare Pls. i–iv, pp. 134–135

Superior Series

Mastodon americanus, r.M²; r.M³ with 4⅓ ridge-crests.

Pliomastodon americanus praetypica, r.M²; r.M³with 4¼ ridge-crests.

Pliomastodon matthewi type, r.M³ with 3⅔ ridge-crests.

Palæomastodon intermedius, r.M³ with 2½ ridge-crests.

Inferior Series

Mastodon americanus, r.M₂; r.M₃ with 4½ ridge-crests.

Pliomastodon americanus praetypica, r.M₂; r.M₃ with 5 ridge-crests.

Pliomastodon matthewi paratypes, M₃ with 4⅕ ridge-crests.

Miomastodon merriami type, r.M₃ with 4⅕ ridge-crests.

Palæomastodon intermedius, l.M₃ with 3 ridge-crests.

Observe: (1) Inferior molars more progressive than superior molars; (2) a) anterior ridge-crests (protoloph, -lophid) relatively constant, b) second ridge-crests (metaloph, -lophid) progressively broadening, c) third ridge-crests (tritoloph, -lophid) progressively broadening, d) fourth ridge-crests (tetartoloph, -lophid) progressively broadening, e) fifth ridge-crests (pentaloph, -lophid) more progressive in M_3 than in M^3; (3) third inferior molar elongate, gently narrowing posteriorly, third superior molar less elongate, more rapidly narrowing posteriorly; (4) *absence* of median trefoil spurs in *Palæomastodon*, presence of external trefoil spurs in *Miomastodon* and *Pliomastodon:* (5) rudimentary ectotrefoil spurs in *Mastodon* inferior molars. Observe (6) that in this figure the grinding teeth of all the true Mastodontinæ exhibit a *median sulcus* and four primary conelets on each ridge-crest; also a rudimentary trefoil spur extending from the entoconelets of the superior molars and from the ectoconelets of the inferior molars. (7) In *Palæomastodon intermedius* the proto- and metaconules *close the median sulcus.*

FINAL RIDGE FORMULÆ.—The ridge formula of the deciduous and permanent teeth of *Mastodon americanus* is as follows (see Warren, 1852, pp. 64–73):

LOWER JAW

Dp_2 small, two ridge-crests, bilophodont.
Dp_3 larger, two ridge-crests and talon, bilophodont.
Dp_4 three ridge-crests, cingulum, trilophodont, six fangs.
M_1 larger, three ridge-crests.
M_2 three ridge-crests.
M_3 four ridge-crests, with complex talon, tetralophodont.

UPPER JAW

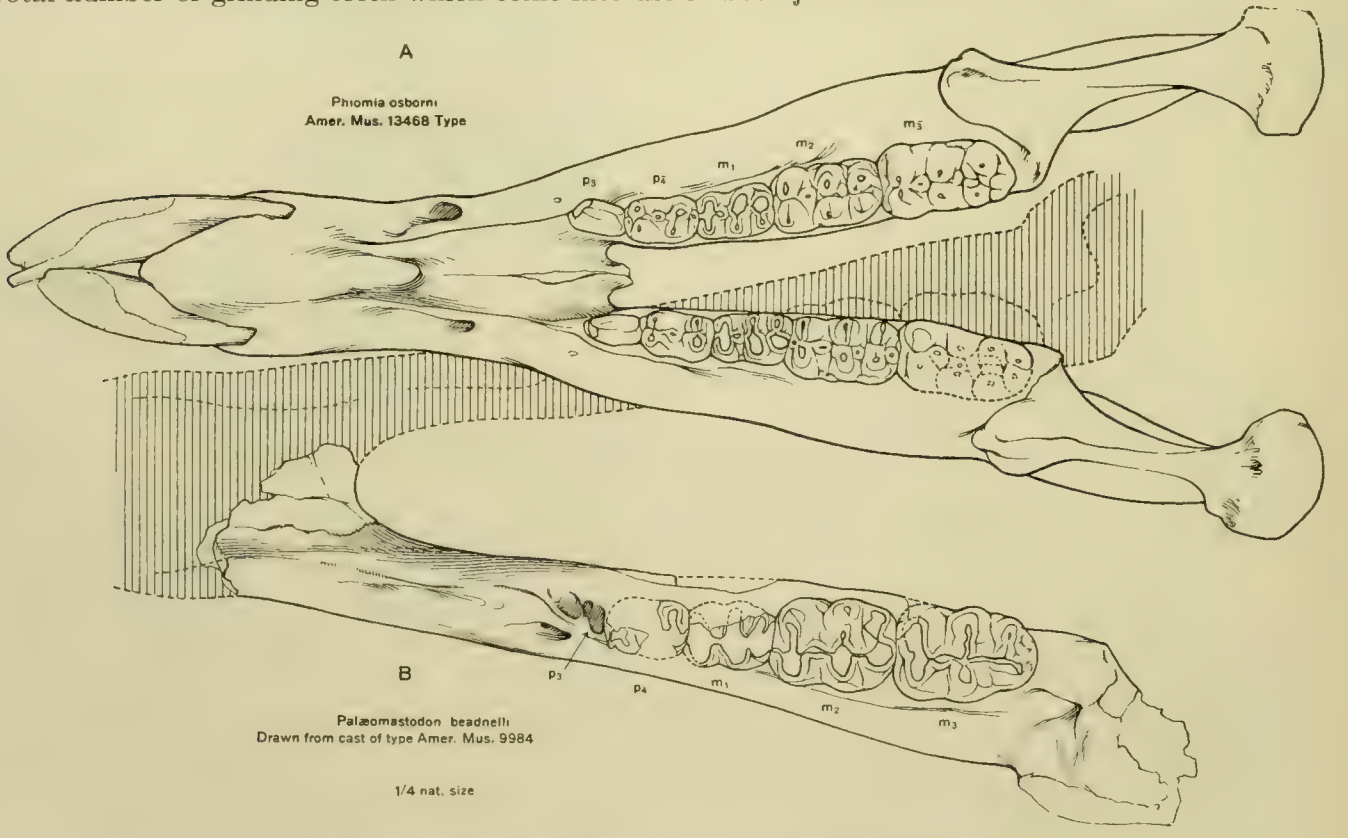
Dp^2 (?) two ridge-crests, bilophodont.
Dp^3 two ridge-crests, bilophodont.
Dp^4 three ridge-crests, trilophodont.
M^1 three ridge-crests, trilophodont.
M^2 three ridge-crests, trilophodont.
M^3 four ridge-crests, and small talon, tetralophodont.

The ridge formula of *Mastodon americanus* appears to be as follows:

$$Dp\ 2\ \tfrac{2}{2}\quad Dp\ 3\ \tfrac{2}{2}\quad Dp\ 4\ \tfrac{3}{3}\quad M\ 1\ \tfrac{3}{3}\quad M\ 2\ \tfrac{3}{3}\quad M\ 3\ \tfrac{4+}{4\ 3/4}$$

The dental formula of *Mastodon americanus* accords with the observations of Hays (1834) and of Warren (1852, p. 63). It would appear from Warren's description that the fourth permanent premolar, P^4-P_4, does not erupt in *Mastodon americanus*. It is known in *Serridentinus productus* to be a bilobate tooth. Thus the final true *Mastodon* stage in the grinding teeth of the Mastodontinæ appears to give us the following dental formula:

Deciduous premolars = $Dp^{2\text{-}4}$-$Dp_{2\text{-}4}$.
Permanent premolars = P4 in germ, P2, P3 suppressed.
Permanent molars = $M^{1\text{-}3}$-$M_{1\text{-}3}$.
Total number of grinding teeth which come into use in both jaws = 24.



MANDIBULAR CONTRASTS: PHIOMIA (UPPER), PALÆOMASTODON (LOWER)

Fig. 90. Superior view of largest known jaws of (A) *Phiomia* and (B) *Palæomastodon* superposed for comparison. One-fourth natural size.

A, Type jaw of *Phiomia osborni* Matsumoto (Amer. Mus. 13468). Observe: (1) The relatively long, narrow grinding teeth; (2) the extremely elongate symphysis extending back between right P_3 and left P_3; (3) an ancestral shovel-tusker (cf. *Amebelodon*); incisive alveoli elongate.

B, Type jaw of *Palæomastodon beadnelli* Andrews (Cairo Mus. C. 10014), drawn from cast of type (Amer. Mus. 9984). Observe: (1) The relatively broad inferior molars; (2) the abbreviated inferior grinding series; (3) the extreme anterior position of mandibular symphysis; (4) incisive alveoli rounded, abbreviate.

6. CHARACTERS OF PALÆOMASTODON AND ITS INCLUDED SPECIES

SUPERFAMILY: MASTODONTOIDEA Osborn, 1921
FAMILY: MASTODONTIDÆ Girard, 1852
Subfamily: PALÆOMASTODONTINÆ subfam. nov.

Osborn, 1934: The genus *Palæomastodon* was originally placed by Osborn, following Matsumoto, in the family Mastodontidæ, subfamily Mastodontinæ, on the basis of the broad similarity of its grinding teeth to those of *Mastodon*. Recent and more intensive observation compels Osborn to remove *Palæomastodon*[1] from its supposed ancestral relationship to *Mastodon* or to any other genus of the Mastodontinæ. We must await further knowledge of this relatively rare animal before we can determine its phyletic relationships.

GENUS: **PALÆOMASTODON** Andrews, 1901

Original reference: Zoologist, 1901, (4), V, Aug. 15, pp. 318, 319, (Andrews, 1901.1); Tageblatt des V Internat. Zool.-Cong., Berlin, No. 6, Aug. 16, p. 4. (Published volume, Verhandlungen, 1902, p. 528). (Andrews, 1901.2).
Genotypic species: *Palæomastodon Beadnelli* (Andrews, 1901.1, pp. 318, 319).

GENERIC CHARACTERS.—(Matsumoto, 1924.1, p. 3): "A genus of Proboscidea. Skull imperfectly known. Palate rather short and wide, as compared with that of the next genus [*Phiomia*]; judging from the form of the palate this genus might be less long-skulled than the next one. Mandible elongated anteroposteriorly; mandibular symphysis rather short as compared with that of *Phiomia;* posterior end of symphysis lying a considerable distance anterior to the first cheek tooth (P_3); largest and most conspicuous one of mental foramina lying just below the first cheek tooth, and far behind the posterior end of the symphysis. Dental formula: $I\frac{?}{?}$. $C\frac{0}{0}$. $P\frac{3}{2}$. $M\frac{3}{3}$. Ridge formula: $Dm\frac{?\,?\,?}{?\,?\,?}$. $P\frac{1-1-2}{1-2}$. $[M\frac{2\frac{1}{2}-3}{3-3}]$.[2] Cheek teeth markedly brachyodont; last premolars and all molars short and wide, bunolophodont, wearing like typically lophodont teeth, attaining rather sharp ridges and very widely open valleys when moderately worn; a rudimentary intermediate cusp is present in the anterior valley of each lower molar; no trefoil pattern of cusps; surface of enamel rather smooth; basal cingula neither very strong nor very rough."

As pointed out clearly in Chapter II, Sections II–IV, the genus *Palæomastodon*, based on the genotype *P. beadnelli* and now amplified by our present knowledge of the species *P. parvus* Andrews and *P. intermedius* Matsumoto, represents a group of species entirely distinct from the *Phiomia* group. Inasmuch as Andrews' final definitions (1906, p. 130) both of the genus *Palæomastodon* and of the family Palæomastodontidæ based on this genus are entirely founded on the generic characters of *Phiomia*, we are compelled with regret to abandon Andrews' definition both of the genus *Palæomastodon* and of the family Palæomastodontidæ and to substitute, with a few omissions and slight modifications, the definition of Matsumoto which is founded on a correct diagnosis of the characters of *Palæomastodon* so far as known. In *Palæomastodon* the lower incisors are apparently *short* and *rounded;* in *Phiomia* they are *long* and *flattened.*

The above generic characters are confirmed and amplified in the three ascending species included within this genus and distinguished by measurements as follows:

Palæomastodon parvus Andrews, 1905	*Palæomastodon intermedius* Matsumoto, 1922	*Palæomastodon beadnelli* Andrews, 1901
Length of lower molar series, M_{1-3}, 130–131 mm.; of lower premolar-molar series, P_3-M_3, 169 mm.	Length of lower molar series, M_{1-3}, 159–161 mm.; of lower premolar-molar series, P_3-M_3, 190e mm.	Length of lower molar series, M_{1-3}, 191–194 mm.; of lower premolar-molar series, P_3-M_3, 279 mm.

RARITY OF PALÆOMASTODON REMAINS.—The relative rarity of specimens referable to the three species of *Palæomastodon* is very significant indeed; in the collections of the British, Cairo, and American museums combined the total number of specimens of teeth and jaws referable to these three species may be approximately enumerated as follows:

[1](1935) Now placed in the new subfamily PALÆOMASTODONTINÆ (see Appendix).
[2]The Matsumoto ridge formula (1924.1, p. 3) of *Palæomastodon* is apparently a *lapsus calami* or a misprint. [The ridge formula in *Palæomastodon beadnelli* and *P. intermedius* is: $M\,1\,\frac{2\,1/2}{3}$ $M\,2\,\frac{2\,1/2}{3}$ $M\,3\,\frac{2\,1/2}{3}$.]

Palæomastodon parvus: 4 specimens Brit. Mus., 1 specimen Amer. Mus., total	5
Palæomastodon intermedius: 4 specimens Amer. Mus.	4
Palæomastodon beadnelli: 2 specimens Cairo Mus., 2 specimens Amer. Mus., total	4
Grand total skull, tooth, and jaw specimens certainly referable	13

In the American Museum collection there are *seven* specimens of *Palæomastodon* and *seventy-nine* specimens of *Phiomia,* the relative frequency of *Palæomastodon* to *Phiomia* being as one to eleven.

Osborn, 1934: We observe (Figs. 91–93) that the progressive third superior and inferior molars of *Palæomastodon intermedius* exhibit the *presence* of proto- and metaconules, hence hexabunodont; these conules *block the median sulcus* which distinguishes the genera *Mastodon, Zygolophodon, Turicius,* and *Stegolophodon* (as shown in Pls. I–IV, pp. 134–135). These characters remove *Palæomastodon* from the ancestry of the Mastodontinæ.

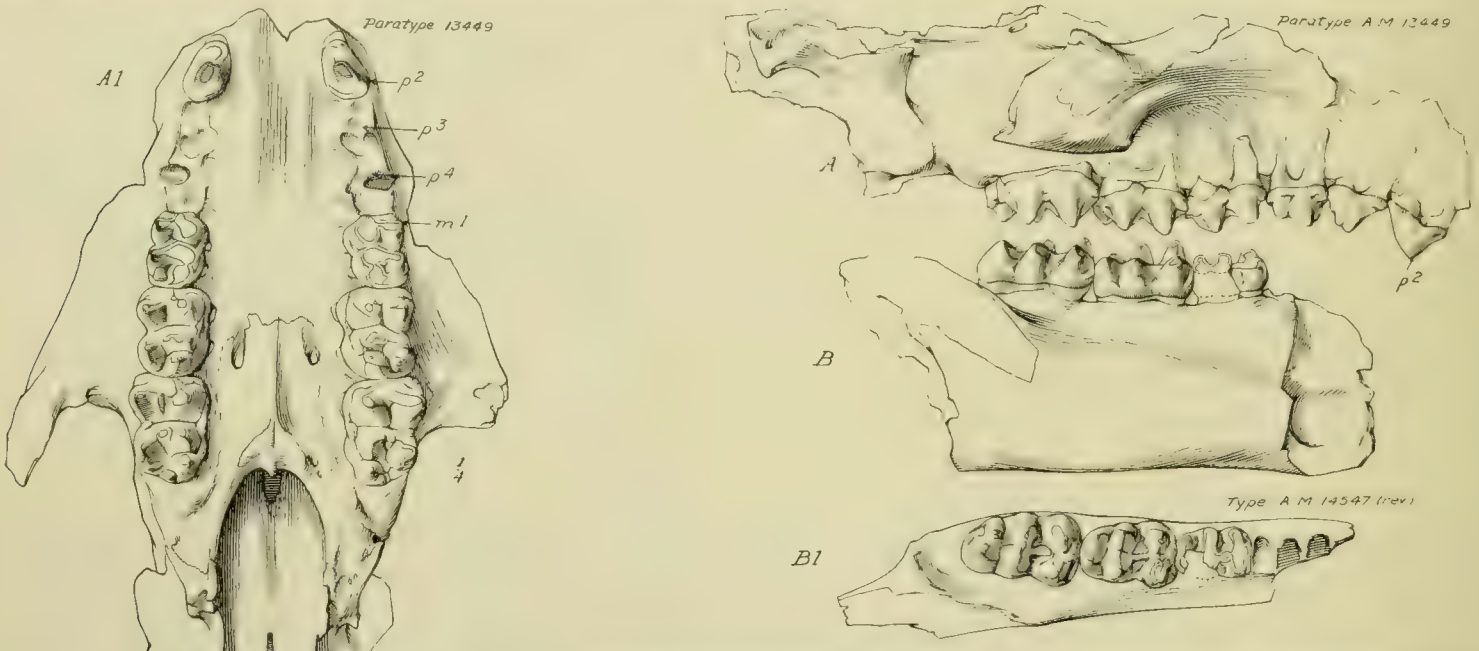


Fig. 91. Type and paratype specimens of *Palæomastodon intermedius* Matsumoto, 1922, one-fourth natural size. Drawings prepared under the direction of Dr. H. Matsumoto.

B, Type of *Palæomastodon intermedius* Matsumoto, 1922, Amer. Mus. 14547 (reversed in drawing). B1, Crown view of the same type specimen (reversed in drawing).

A, Paratype palate of *Palæomastodon intermedius* (Amer. Mus. 13449); P^3, P^4 drawn in from Amer. Mus. 14548 (reversed). A1, The same paratype specimen, palatal view.

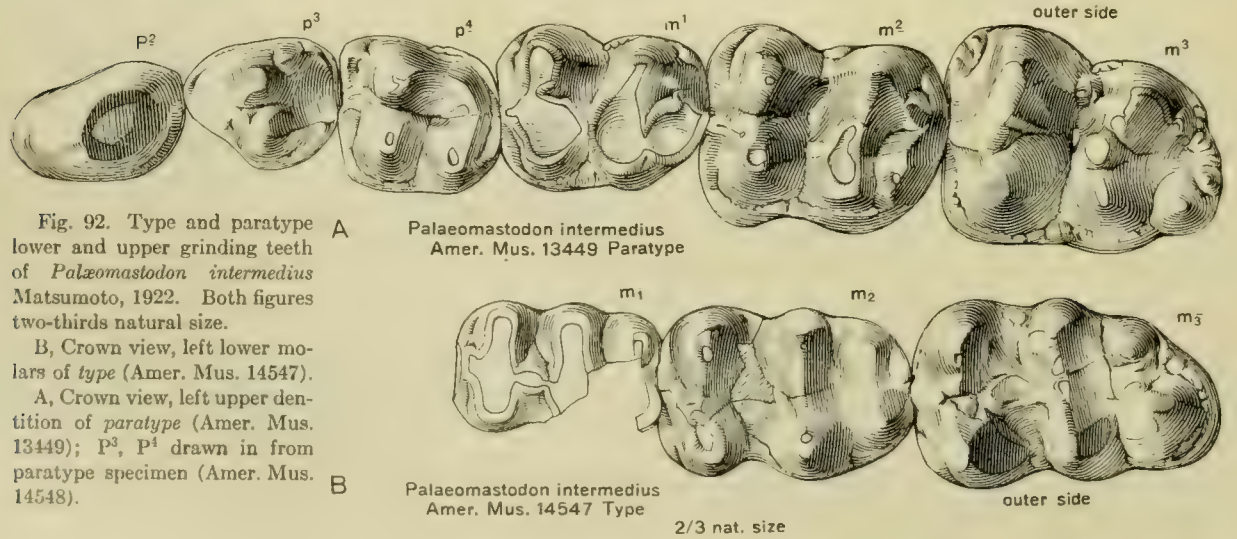


Fig. 92. Type and paratype lower and upper grinding teeth of *Palæomastodon intermedius* Matsumoto, 1922. Both figures two-thirds natural size.

B, Crown view, left lower molars of *type* (Amer. Mus. 14547).

A, Crown view, left upper dentition of *paratype* (Amer. Mus. 13449); P^3, P^4 drawn in from paratype specimen (Amer. Mus. 14548).

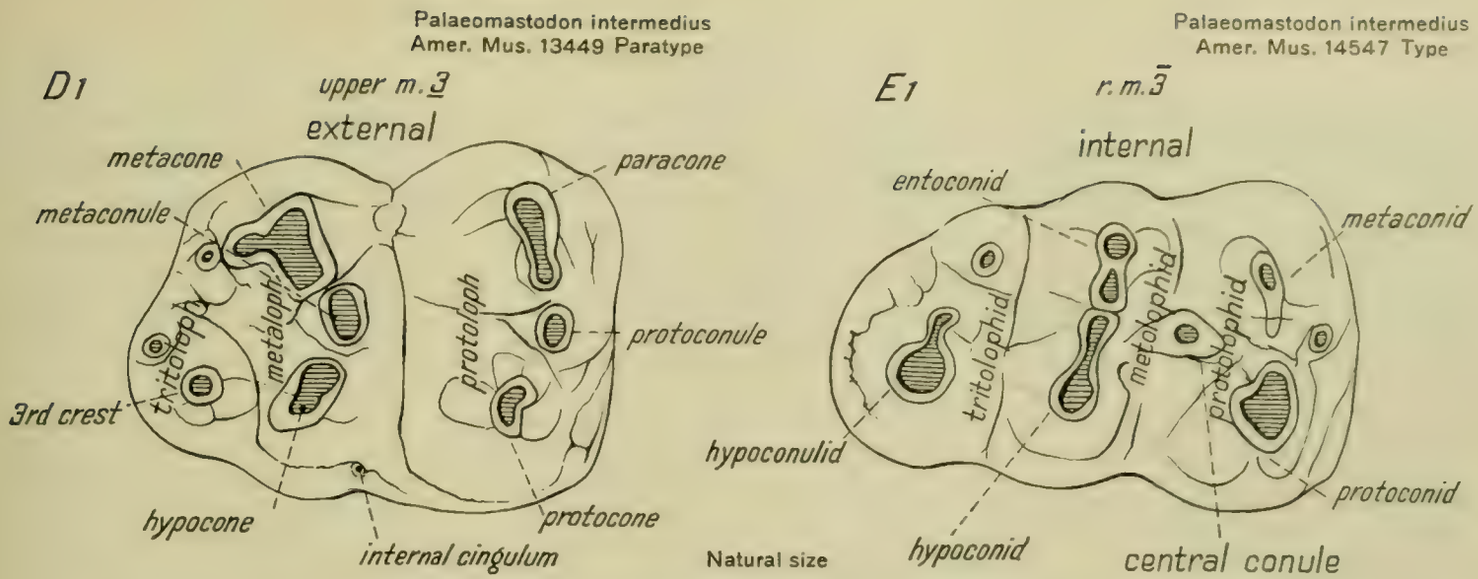


Fig. 93. Key to the hexabunodont upper and lower molar crowns of *Palæomastodon intermedius;* M_3 drawn from the type (Amer. Mus. 14547), M^3 from the paratype (Amer. Mus. 13449). See figure 92A, B, for same type and paratype. Natural size.

Observe: (1) *Relatively broad* proportions; (2) hexabunodont crowns of M^3, namely, protocone, protoconule, paracone, hypocone, metacone, metaconule; (3) fundamental arrangement in two transverse crests, i.e., protoloph, metaloph; (4) two intermediate cusps, i.e., protoconule, metaconule; (5) lower molar M_3 has rudimentary trilophodont crown; (6) both upper and lower molars wholly distinct in proportions from those of any species of *Phiomia*; (7) *central conule* rudiment in M_3; (8) absence of median sulcus.

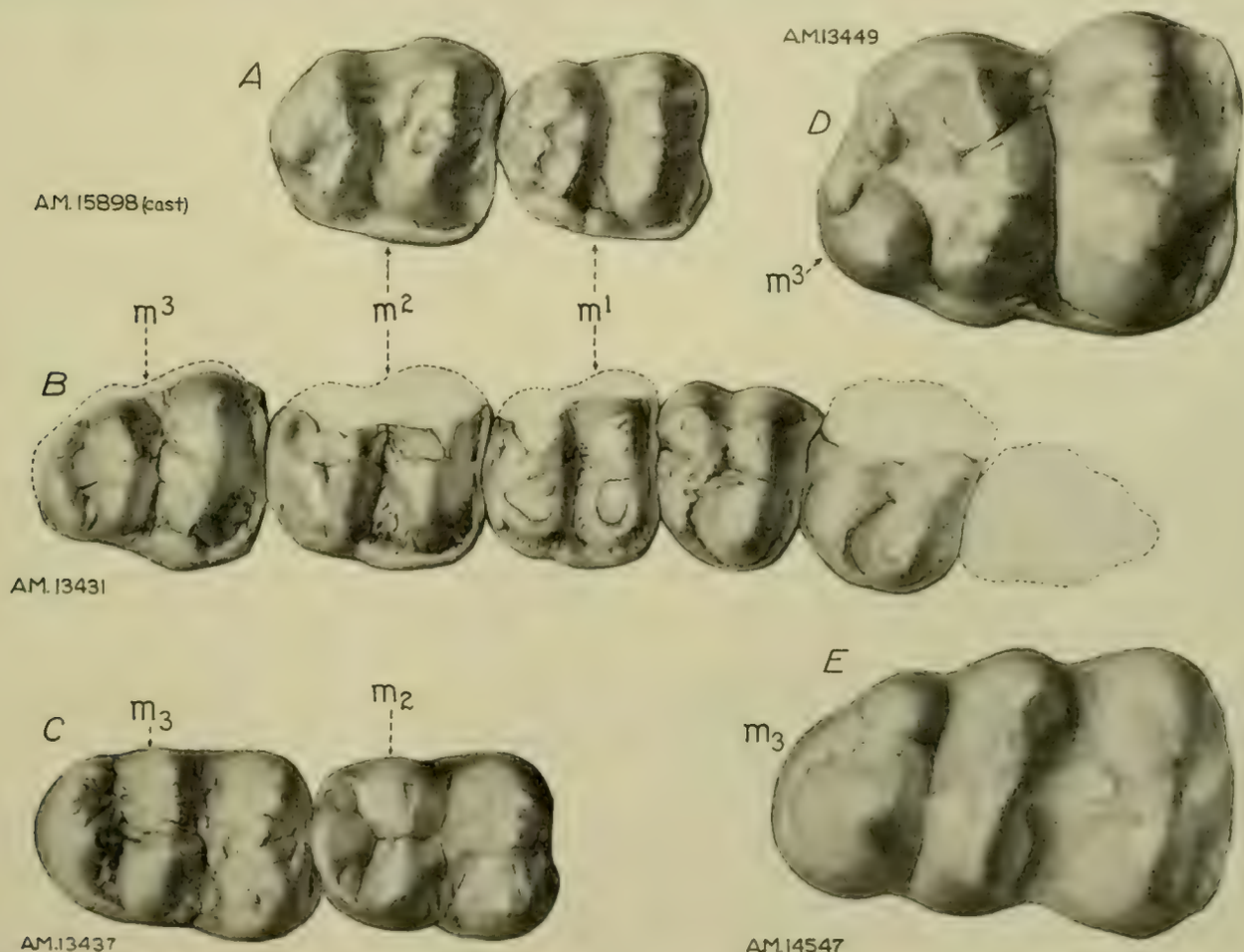


Fig. 94. Detailed studies of: True *Palæomastodon intermedius* third superior and inferior *hexabunodont* (D, E) teeth, M^3-M_3, compared with the essentially *tetrabunodont* (A, B, C) *Mæritherium* teeth, superior and inferior. From originals and casts in the American Museum. All figures natural size.

A, *Mæritherium lyonsi* ref., right M^{1-2} drawn from cast Amer. Mus. 15898.

B, *Mæritherium trigodon* ref., right superior grinders drawn from Amer. Mus. 13431.

C, *Mæritherium andrewsi* ref., left M_{2-3} drawn from Amer. Mus. 13437.

D, *Palæomastodon intermedius* paratype, third right superior molar, r.M^3, Amer. Mus. 13449.

E, *Palæomastodon intermedius* type, third left inferior molar, l.M_3, Amer. Mus. 14547 (reversed in drawing).

Confusion of Palæomastodon beadnelli with Phiomia wintoni.—As Matsumoto remarks, the greater portion of Andrews' descriptions and all his text figures of *Palæomastodon beadnelli*, except those of the type jaw and teeth, belong not to this species but to *Phiomia wintoni*. All the principal specimens of skulls and upper jaws referred by Andrews to *Palæomastodon beadnelli* also appear to belong to *Phiomia wintoni*, except the specimen (Cairo Mus. C.10014a) illustrated in his Pl. xv, fig. 2, representing a fragment of a maxilla with the second and third molars, M^2-M^3, *in situ* which appears to truly belong to *P. beadnelli;* these teeth are clearly shown to be bilophodont, a generic character of the *Palæomastodon* superior molars.

Palæomastodon parvus Andrews, 1905

For original description and type figure, see pp. 59, 60, of the present Memoir.

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

This is the smallest and most primitive *Palæomastodon* known; it is probably of much greater geologic age than *P. beadnelli*, the first species discovered. The full characterization of this species in the systematic revision of Chapter II above and the comparative measurements as given by Matsumoto and corrected by Osborn leave little to be added. It is a relatively rare animal because it is known at present from only five specimens, namely, the type (Brit. Mus. 8479a) and three other specimens in the British Museum, also referred Amer. Mus. 13497.

Specific Characters.—The specific characters cited in Chapter II from Andrews (1905, p. 562) and Matsumoto (1922, p. 2, 1924.1, p. 4), together with corrected measurements by Osborn, may be summed up in the following sentence: *P. parvus* is distinguished by (1) $M_{1\text{-}3}$ 131 mm. as compared with 161 mm. in *P. intermedius* and 194 mm. in *P. beadnelli*, (2) P_3-M_3 169 mm. as compared with 190e mm. in *P. intermedius* and 279 mm. in *P. beadnelli*, (3) molar proportions of $M_{1\text{-}3}$ substantially similar to those in *P. intermedius* and *P. beadnelli*.

Palæomastodon intermedius Matsumoto, 1922

For original description and type figure, see pp. 63, 64.

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

As the name *intermedius* indicates this animal is intermediate in size between *Palæomastodon parvus* and *P. beadnelli;* it is more progressive than the former species in its molar teeth, the molars being relatively *narrower*. It is known from four specimens only.

Geologic Level of Four Specimens.—The quarry records show that the level of the type (Amer. Mus. 14547) is not recorded; one paratype (Amer. Mus. 13480) is from Quarry B, another paratype (Amer. Mus. 13449) is from Quarry A, while a third, a maxilla (Amer. Mus. 14548), is not recorded. As shown in Chapter II, systematic revision of *Palæomastodon intermedius* above, there is no means of ascertaining the exact geologic levels of the different species of *Palæomastodon;* all that we can say is that the species *P. intermedius* is well represented by the *four* specimens in the American Museum collection, clearly illustrated in figures 39, 91–94.

Specific Characters.—Osborn confirms Matsumoto's separation and definition of this species and adds the following characters which are clearly displayed in figures 92 and 94: (1) The hexabunodont structure of M^3, less strongly indicated in M^2 which is tetrabunodont; (2) the sublophodont arrangement of the cones and conules both in the superior and inferior molars; (3) the arcuate arrangement of the superior and inferior molars of opposite sides. In addition to the specific characters quoted in full from Matsumoto in Chapter II (Matsumoto, 1922, p. 2, 1924.1, p. 10, and extended by Osborn), it may also be pointed out that the grinding teeth of *P. intermedius*, besides being of smaller dimensions throughout, are relatively narrower than those in the type of *P. beadnelli*, namely:

	M_1	M_2	M_3
Palæomastodon beadnelli, type indices	77	78	68
Palæomastodon intermedius, type indices	64	66	62

It may be premature, however, to establish these indices as specific characters until we secure more material.

Phylogenetic Relationship.—It would also be premature to say whether *Palæomastodon parvus*, *P. intermedius*, and *P. beadnelli* constitute an ascending series of species increasing in size, losing certain primitive characters and acquiring certain progressive characters. We must await further evidence which will be afforded, first, by the discovery of the complete dental and cranial characters of these primitive mastodonts, and, second, by the determination of the geologic levels in which they occur. Comparing *Palæomastodon* with *Phiomia* the same question will arise in respect to the latter genus, namely, whether the smaller, intermediate, and larger species constitute an ascending series. Tentatively the two lines may be arranged as follows:

Larger, more progressive	*Palæomastodon beadnelli*	*Phiomia osborni*
Intermediate in character	*Palæomastodon intermedius*	*Phiomia wintoni*
Smaller, more primitive	*Palæomastodon parvus*	*Phiomia serridens*
Smaller, more primitive		*Phiomia minor*

Cranial Proportions.—The cranium of *Palæomastodon intermedius* (Amer. Mus. 13449) constitutes the only evidence we have at present as to the proportions of the skull in *Palæomastodon* (see Figs. 91, 39). These proportions are more *brachycephalic* than those of *Phiomia*, as evidenced (1) by the relatively widely arching palatal series, (2) by the harmonically broader and shorter grinding series, and (3) by the more widely arching zygomata. We may expect to find *Palæomastodon* with a broader and a shorter skull than that of *Phiomia*, with a large pair of upper and lower incisive tusks, probably *rounder* than those of *Phiomia*, with a broad

enamel band on the concave outer surface of the upper tusks, as in the Miocene species of *Miomastodon*.

(Matsumoto, 1924.1, p. 9), as well as the following new comparative measurements by Osborn:

DENTAL MEASUREMENTS AND INDICES IN THE THREE SPECIES OF PALÆOMASTODON

	M 1-3	M 1			M 2			M 3			P 3-M 3
INFERIOR MOLARS		ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	
Palæomastodon beadnelli type, Cairo Mus. C.10014	M_1-M_3=194	48	37	77	65	51	78	78	53	68	P_3-M_3=279
" " Amer. Mus. 13481								81	45	56	
" *intermedius* type, Amer. Mus. 14547	M_1-M_3=161	42	27	64	53	35	66	65	40	62	P_3-M_3=190e
" " paratype, Amer. Mus. 13480								60	37	62	
" *parvus* type, Brit. Mus. 8479a (cast Amer. Mus. 9976)	M_1-M_3=131	41	28	68	44	32	73	43	30	70	P_3-M_3=169
" " Amer. Mus. 13497								52	33	63	
SUPERIOR MOLARS											
Palæomastodon intermedius paratype, Amer. Mus. 13449	l. M^1-M^3=150	42	34	81	50	42	84	57	46	81	P^3-M^3=200e
	r. M^1-M^3=149	43	35	81	50	43	86	57	45	79	P^3-M^3=200e

DENTAL CHARACTERS.—The dental characters in *P. intermedius* are beautifully illustrated in figures 93, 94, and especially in figure 92, showing the detail of the upper and lower grinding teeth. We observe that both upper and lower grinders are progressing towards trilophodonty; at the same time the three lobes are showing a tendency to unite into three transverse crests, so that the term trilophodont exactly describes them. This dental structure does not sustain Matsumoto's generalization that the genus *Palæomastodon* includes the ancestral forms of *Mastodon*.

Palæomastodon beadnelli Andrews, 1901

For original description and type figure, see p. 54

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

This is important as the largest and probably the most progressive, as well as the first discovered and genotypic species of *Palæomastodon*.

GEOLOGIC LEVEL.—Andrews (letter, 1922) informs the writer that the large type jaw (see original type figure, Fig. 26) was found at the very base of the Fluvio-marine beds, 50 or 100 feet below the typical *Phiomia* level; this genotype jaw (Cairo Mus. C.10014), with a very large referred femur (Cairo Mus. C.10017), tibia (C.10015), scapula (C.10016), humerus (C.10013), and axis vertebra (C.10061), was the only true *P. beadnelli* material found at this locality. This referred limb material (Fig. 96) is very important because of (1) its primitive *Mastodon*-like characters and (2) its use in estimating the size and limb proportions of *Palæomastodon*, as shown in Andrews' restorations.

SPECIFIC CHARACTERS OF P. BEADNELLI.—The specific characters are shown in the second type figure by Andrews (Fig. 95), in the type jaw as refigured by Osborn in comparison with *Phiomia osborni* (Fig. 90), also in Amer. Mus. 13481 (Fig. 187, Pl. I, p. 134), a right lower third molar, M_3, attached to a small fragment of a mandibular ramus from Quarry B, measuring 81 mm. in length and 45 mm. in width. See Matsumoto's definition in the systematic revision above; also his detailed comparative measurements

SIGNIFICANT MOLAR INDICES.—The dental proportions of *Palæomastodon* are shown in the molar indices M^1-M_1, M^2-M_2, M^3-M_3 as above. The molar indices (I.) in the three species of *Palæomastodon* are printed above as showing the ratio of transverse (tr.) to anteroposterior (ap.) measurement; although greatly modified by crushing of the teeth (as for example in comparison of Amer. Mus. 13481 with Cairo Mus. C.10014) they nevertheless serve to distinguish *Palæomastodon* very clearly from *Phiomia*, as shown in the following contrast:

RATIOS (I.) OF BREADTH (TR.) TO LENGTH (AP.) IN PALÆOMASTODON AND PHIOMIA

	M_1	M_2	M_3
Palæomastodon beadnelli type indices	77	78	68
Phiomia wintoni average.....	68	62	56

Fig. 95. Second type figure of *Palæomastodon beadnelli* Andrews, 1901. After Andrews' "Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt," Pl. XV, figs. 1, 1A, 1906. Original type in Geological Museum, Cairo (C. 10014). One-sixth natural size.

From this comparison we see that whereas in species of *Palæomastodon* the breadth of M_3 is from 62% to 70% of the length, in species of *Phiomia* the breadth of M_3 is from 54% to

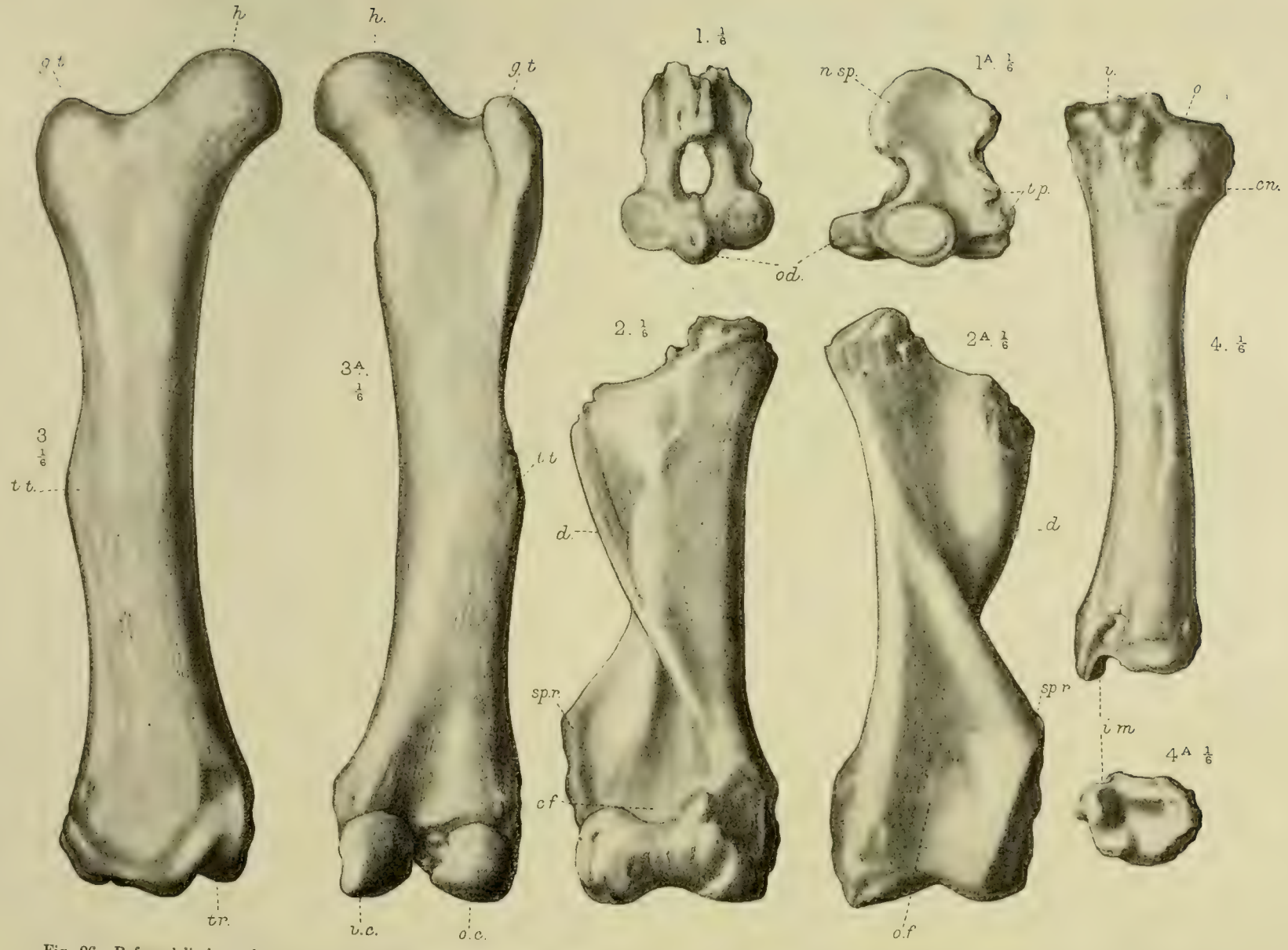


Fig. 96. Referred limbs and vertebræ of *Palæomastodon beadnelli*. After Andrews, 1906, Pl. xvi. Of the humerus, femur, scapula, and other bones described in detail by Andrews (1906, pp. 143–149), the only ones that can with probability be referred to *Palæomastodon beadnelli* are the following: Axis vertebra, Cairo Mus. (C 10061), scapula (C.10016), humerus (C. 10013), femur (C. 10017), and tibia (C. 10015).

63% of the length. Thus the indices in *Palæomastodon* of 62% to 70% are uniformly broader than those in *Phiomia* of 54% to 63%. These *molar indices* therefore are very profound and significant characters, because the *molar indices* of *Palæomastodon* point towards those of *Mastodon;* the *molar indices* of *Phiomia* point towards those of *Trilophodon.* For example, in *Serridentinus productus* (Amer. Mus. 10582) the third molar indices are 47-60, the proportions of M_3 being about the same as in *Phiomia wintoni.*

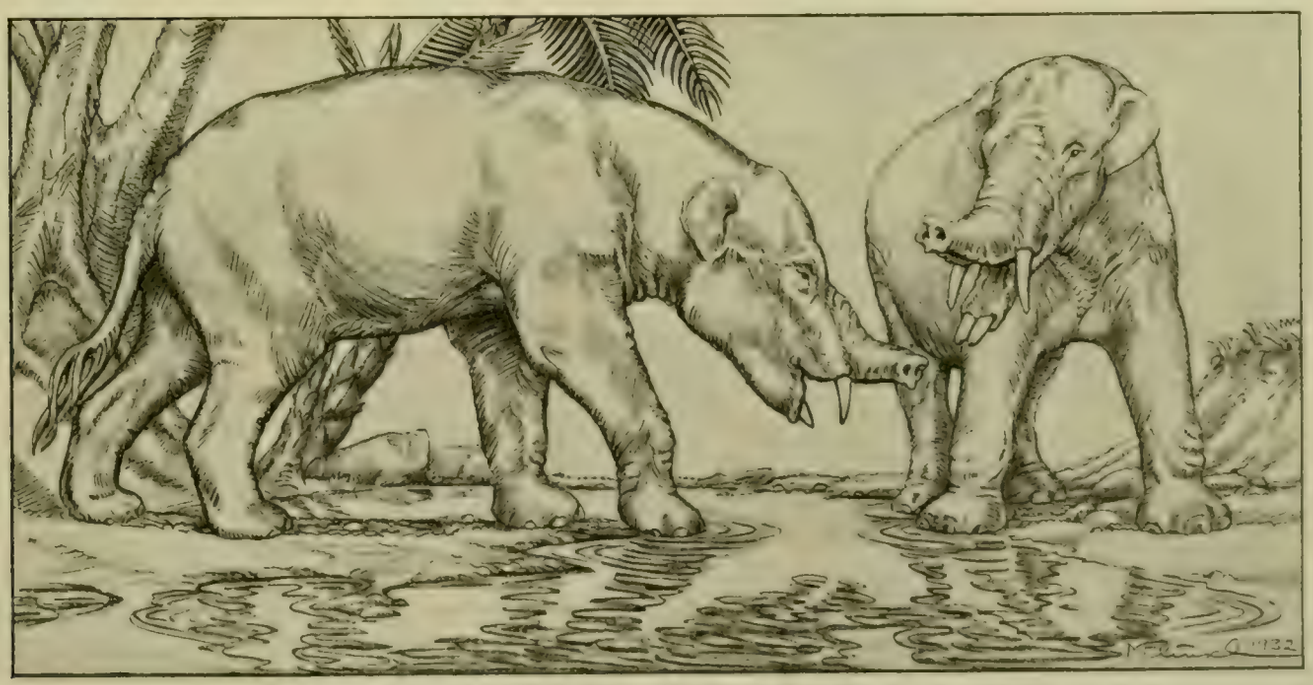
In *Palæomastodon* the lower molars are relatively shorter and broader; in *Phiomia* they are relatively longer and narrower. There is a less wide contrast in the upper molars.

Characters of the Skeleton.—Andrews (1906, pp. 145–147) observes of the only bones found in the same locality as the type of *P. beadnelli* as follows:

"*Fore limb.*—An incomplete left *scapula* collected in the same locality as the type mandible is the only evidence of that bone yet discovered. It is very closely similar to the scapula of *Elephas,* differing only in the rather slighter prominence of the coracoid process and in widening out less rapidly posteriorly above the glenoid cavity, the whole blade being probably rather less expanded above than in *Elephas.* The glenoid cavity is an elongated oval, the prescapular fossa is extremely narrow, and the process projecting backwards from the middle of the spine in *Elephas* here seems to be situated a little nearer the glenoid end. In the case of the *humerus* (Pl. xvi. figs. 2, 2a) also the only specimen that can be definitely determined as belonging to *Palæomastodon beadnelli,* was collected near the type mandible. In its general character this bone is like that of the later Proboscideans, but is somewhat stouter and broader in proportion to its length, and approaches more nearly some specimens of the humerus of *Mastodon* with which it has been compared. . . . A *femur* (Pl. xvi. figs. 3, 3a) from the same locality is the only specimen of that bone in the collections of Cairo and London that is definitely Proboscidean in character and can be referred to *Palæomastodon*—a circumstance which still further emphasises the extraordinary rarity of bones of the skeleton of that animal. . . . A left *tibia* (Pl. xvi. figs. 4, 4a) from the same locality is, on the whole, like that of the Elephant. It is, however, rather more slender in the shaft, and the distal articulation differs in several important points. . . . No bones of the foot were found with the limb-bones just described, but a single *calcaneum* (text-fig. 51), from some distance off, so nearly resembles in essential characters the calcaneum of the later Proboscideans, more particularly of the Lower Miocene *Tetrabelodon angustidens,* that it may be safely referred to *Palæomastodon,* and from its large size probably belongs to *P. beadnelli.*"

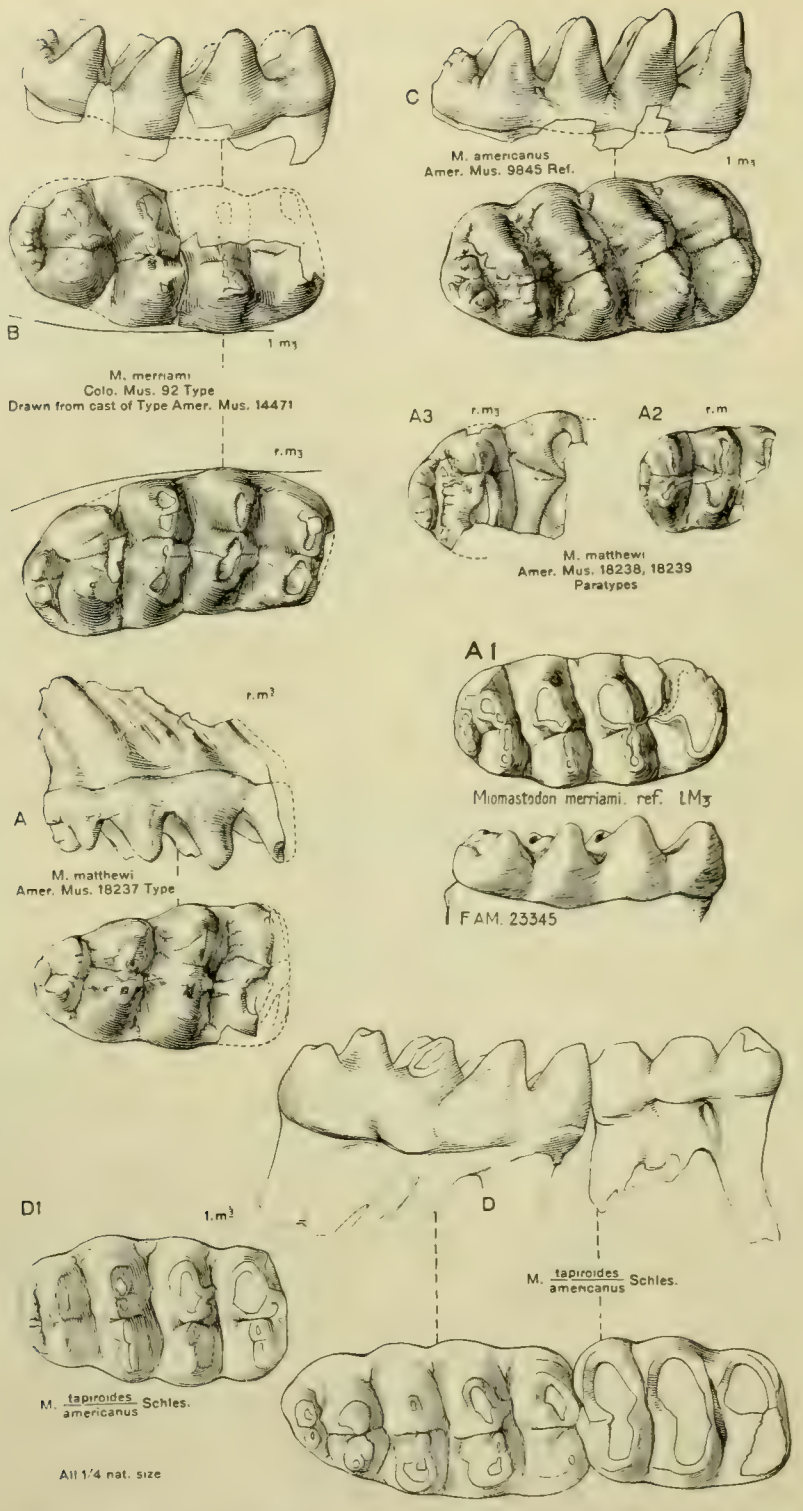
Andrews combined these materials, probably chiefly referable to *Palæomastodon beadnelli,* with other bones probably referable to *Phiomia wintoni* to produce his reconstructions of the animal. It is probable that the skeletal parts which he referred to *Palæomastodon parvus* belong to the species *Phiomia minor.*

Osborn's restorations of *Palæomastodon* as a forest browser (Figs. 2, 97) are entirely different both as to form and function from Osborn's restorations of *Phiomia* (Figs. 2, 17) as an ancestral shovel-tusker.



Restoration (1932) of Palæomastodon as a Forest Browser
By Margret Flinsch, under the direction of Henry Fairfield Osborn
Skeletal parts after Andrews, 1906, Pls. xv, xvi (Fig. 96 of the present Memoir)

Fig. 97. The rarity of *Palæomastodon beadnelli* in the Fluvio-marine beds, as compared with the great abundance of *Phiomia,* indicates that this was a forest-living animal which rarely entered the *Phiomia* habitat. Forest-living animals throughout the entire Tertiary are not often found fossil in association either with plains-living, palustral, or amphibious forms. For limb proportions of this restoration, see figure 96 opposite. Osborn, 1934: The restoration of the primitive proboscis and of the single pair of lower incisive tusks may prove to be incorrect; we await further knowledge of the anterior portions of the upper and lower jaws and of the tusks.



MIOCENE AND PLIOCENE TRUE MASTODONS, MIOMASTODON AND PLIOMASTODON OF EUROPE AND AMERICA. COMPARE PL. I, PP. 134–135

Fig. 98. Comparison of the type molars of *Miomastodon* and of *Pliomastodon* of the Miocene and Pliocene and of the true *Mastodon americanus* of the Pleistocene of America and Europe. After Osborn, 1921.522, fig. 1, except A1, which is after Frick, 1933, fig. 28. All figures one-fourth natural size.

A, Type, r.M^3, of *Miomastodon* [=*Pliomastodon*] *matthewi* Osborn, Snake Creek B, Pliocene, Nebraska. Amer. Mus. 18237.

A2, A3, Paratypes of *M.* [=*P.*] *matthewi*. Same locality as type. Amer. Mus. 18238, 18239.

A1, L.M_3 of *Miomastodon merriami* ref., Pawnee Creek formation, Middle Miocene, Colorado (F:A.M. 23345). After Frick, 1933, fig. 28.

B, Type, l.M_3 and r.M_3, of *Miomastodon merriami*, Virgin Valley formation, Middle Miocene, Nevada, Colo. Mus. 92; cast Amer. Mus. 14471. See also figure 99 for superior molars and tusks of same type.

C, Referred molar, l.M_3, of *Mastodon americanus*, from the phosphate beds of South Carolina, in the American Museum (Amer. Mus. 9845).

D, D1, Originals after photographs by Schlesinger. Types, l.M_2-l.M_3, l.M^3, *Mastodon tapiroides americanus* Schlesinger, Tasnád, Usztató Kom., Hungary. Lower Pliocene. Compare Schlesinger, 1922, Taf. XIV, fig. 1 [=*Miomastodon tapiroides americanus* of the present Memoir].

7. CHARACTERS OF MIOMASTODON AND ITS INCLUDED SPECIES

SUPERFAMILY: MASTODONTOIDEA Osborn, 1921
FAMILY: MASTODONTIDÆ Girard, 1852
SUBFAMILY: MASTODONTINÆ Brandt, 1869—Osborn, 1910.

GENUS: **MIOMASTODON** Osborn, 1922

Original reference: Amer. Mus. Novitates, No. 49, p. 4 (Osborn, 1922.564).
Genotypic species: *Mastodon merriami* Osborn, 1921.

GENERIC CHARACTERS OF MIOMASTODON (COMPARE OSBORN 1922.564, P. 4).—A genus of the Mastodontinæ apparently directly ancestral to *Pliomastodon* and *Mastodon*. Skull and skeleton unknown. Dental formula incompletely known: $I\frac{0\text{-}2\text{-}0}{0\text{-}2\text{-}0}$ $Dp\frac{?}{?}$ $P\frac{?}{?}$ $M\frac{1\text{-}3}{1\text{-}3}$. Incisive tusks with broad enamel band, broadly suboval in section, downturned (*M. merriami*). Grinding teeth somewhat more elevated than in *Palæomastodon;* much less elevated (subhypsodont) than in *Mastodon*. Ridge formula probably: $P\,4\frac{3}{3}$ $M\,1\frac{3}{3}$ $M\,2\frac{3}{3}$ $M\,3\frac{4}{4\ 1/3\text{-}5}$. Crests on the 'intermediate molars' probably fully formed, i. e., trilophodont. Internal and external lobes (i.e., cones) of each loph separated by median or longitudinal sulcus, as in *Mastodon;* summit of each lobe (i.e., cone) double or bifid (Fig. 98B) as in *Mastodon*, unlike *Palæomastodon* in which there is no longitudinal sulcus. Each lobe transversely oval in horizontal section but less compressed anteroposteriorly than in *Mastodon*. Lower tusks rodlike, horizontal, vertically oval.

The above generic characters are confirmed, amplified, and slightly modified in the four ascending species included within the genera *Miomastodon* and *Pliomastodon* and distinguished as follows:

Miomastodon[1]		*Pliomastodon*	
Miomastodon merriami Osborn, 1921. Genotypic species (Colo. Mus. 92).	*Miomastodon tapiroides americanus* (Schlesinger in Osborn, 1921). Type. (Fig. 98D, D1.)	*Pliomastodon americanus praetypica* Schlesinger, 1919–1922. Cotypes. (Fig. 103.)	*Pliomastodon matthewi* Osborn, 1921. Type (Amer. Mus. 18237); paratypes (Amer. Mus. 18238, 18239). (Fig. 98A).
Tusks concave on outer side, with broad enamel band, down- and out-turned. Lower tusks rodlike, horizontal, vertically oval.	Incisive tusks with broad enamel band on convex external surface.	Incisive tusks not determined.	Superior(?) incisive tusks rounded, upturned, enamel band vestigial or absent.
M_3 measures 179 mm. anteroposteriorly, transverse 83 mm.: $M_{2\text{-}3}$ measure 10½ in. (=269 mm.).	Ridge-crests brachyodont or subhypsodont, as in *M. merriami;* less erect than in *P. matthewi;* $M_{2\text{-}3}$ measure 284 mm. anteroposteriorly.	Estimated length of third superior molar, M^3, 144 mm., of third inferior molar, M_3, 190 mm. $M^{2\text{-}3}$ measure 246 mm., $M_{2\text{-}3}$ measure 304 mm. In size nearly equal to molars of *Mastodon americanus:* $M^{2\text{-}3}$ measure 311 mm., $M_{2\text{-}3}$ measure 330 mm.	Lobes of grinders slightly more elevated or subhypsodont. Second inferior molar, M_2, measures 85c mm., anteroposteriorly; third superior molar, r.M^3, measures 145c mm. anteroposteriorly.
Middle Miocene of Nevada and Colorado.	Lower Pliocene of Hungary.	Middle Pliocene of Hungary.	Lower Pliocene of Nebraska.

The genotypic species of *Miomastodon* is *Mastodon merriami* Osborn (Figs. 98B, 99) from the Middle Miocene, Virgin Valley formation, Nevada; it is distinguished by low-crowned grinding teeth, especially by the *persistence* of a broad enamel band on the outer side of the superior incisive tusks. The geologically succeeding species *Mastodon matthewi* becomes genotypic of the new genus *Pliomastodon*, which entirely lacks the enamel on the incisive tusks, as also probable in *Mastodon americanus praetypica* Schles.; moreover, the ridge-crests in *Pliomastodon* are somewhat more elevated (compare Figs. 89, 98, 102, 394).

The genotypic specimens (Fig. 98B, 99) from the Middle Miocene of Nevada are now reinforced by the more complete referred specimen (Fig. 100) recently discovered by Frick in the Pawnee Creek, Colorado, which fortunately reveals the lower jaw and tusks.

[1]The new and very primitive species *Miomastodon depereti* of the Lower Miocene of France is described in the Appendix at the close of the present Volume. See also comparative Pl. I, pp. 134–135, also figs. 138A, and 230D.

Discovery of Miomastodon and Pliomastodon in Europe and America.—We owe to Schlesinger the discovery of several very distinctive specimens related to the true Mastodon from the Lower and Middle Pliocene of Hungary, to which he gave the name *M. tapiroides americanus;* original photographs of these specimens were kindly forwarded to the author of the present Memoir, who commented (Osborn, 1921.522, p. 2) as follows: "There cannot be the least doubt, however, as to the affinity [to the true Mastodon] of the grinding teeth found in the Lower Pliocene of Hungary, to which Schlesinger applies the name *M. tapiroides americanus.* These teeth are reproduced herewith (Fig. 1, D, D1) from unpublished photographs, kindly forwarded by the author, to the same scale with corresponding grinders (A, A1, A2, A3) from the Lower Pliocene, Snake Creek formation, of western Nebraska, also with lower teeth (B) from the Middle Pliocene [Middle Miocene, Virgin Valley formation], near Thousand Creek, Nevada, and with (C) the posterior lower molar of *M. americanus* from the American Pleistocene." The figure alluded to in this citation (Fig. 1) is reproduced as figure 98 of the present Memoir, the lettering of the plate being unchanged, but with the substitution of *M. merriami* ref. (A1) for the erroneous paratype of *P. matthewi.*

Osborn, 1921.—In the same article Osborn (Osborn, 1921.522, p. 2) published under the name of Schlesinger the species "*Mastodon tapiroides americanus* Schlesinger" based, as described in detail below, upon "upper and lower grinders from the Lower Pliocene, Tasnád, Usztató Kom., Hungary," embracing "a third left superior molar (Fig. 1, D1, see Pl. xiii, fig. 5 [error, H. F. O.], Schlesinger), also two left inferior molars, m_2-m_3 (Fig. 1, D, see Pl. xiv, fig. 1, Schlesinger). The linear measurement of the crowns agrees closely with that of the Pleistocene *M. americanus*, but the vertical measurement is apparently less, i.e., less hypsodont. This indicates that already in the Lower Pliocene the mastodonts had attained the massive proportions of their Pleistocene descendants. The lophs are similarly composed and show no trace of a trefoil ridge. There is nothing to debar these Lower Pliocene mastodonts of Hungary from the true ancestral line of our Pleistocene *Mastodon.*"

The type incisive tusks of *Mastodon tapiroides americanus* Schlesinger from the Lower Pliocene of Hungary agree with the type incisive tusks of *Mastodon merriami* from the Middle Miocene, Virgin Valley formation, near Thousand Creek, Humboldt County, Nevada, in the presence of a broad enamel band; as Osborn observed (*op. cit.*, p. 4), "A very important character is the presence of broad enamel bands on the upper tusks (Fig. 2, C, D, E), which are perhaps similar to the enamel bands observed by Schlesinger in the true Miocene and Pliocene mastodons of Hungary."

In the same communication (pp. 4, 6, Figs. 1B and 2) the species *Mastodon merriami* Osborn was founded upon two left lower molars and portions of the upper molars and of the two upper tusks (Colo. Mus. 92) discovered in April, 1909, in the Virgin Valley formation, Middle Miocene age, near Thousand Creek, Humboldt County, Nevada. These teeth, *constituting the first evidence of the arrival of the true Mastodon in America,* were discovered, as described by the geologist Mr. Richard C. Hills, in a formation consisting of more or less stratified volcanic ash containing much opalized wood. Mr. Hills presented his priceless specimens to the Colorado Museum of Natural History (Colo. Mus. 92) and they were loaned by Director Figgins to the present author and figured as the types of *Mastodon merriami* (*op. cit.*, figs. 1, 2).

In Science, 1921 (Osborn, 1921.523), these discoveries were summed up as follows:

> If the *Mastodon merriami* of Nevada proves to be of Middle Miocene age, it will demonstrate that these true mastodons came to this country much earlier than we have been led to suppose.
>
> I am greatly surprised and interested by the Middle Miocene appearance of the true mastodons in America, if the above report by Dr. Merriam is correct, as I have no doubt it is. Middle Miocene age is, in fact, quite consistent with the structure of the superior . . . tusks, which bear a broad enamel band on a *concave* outer side, a fact that puzzled me greatly because Dr. Schlesinger describes the Lower Pliocene mastodons of Hungary as bearing an enamel band on a *convex* outer surface. We should expect the earlier mastodons to show just the difference in the curvature of their tusks which these two observations would indicate.

Middle Miocene of America and Eurasia.—A year later (1922) Osborn realized that the presence of a *broad enamel band* on the incisive tusks in these three species necessitated their separation from the true genus *Mastodon*, and he accordingly proposed (Osborn, 1922.564, p. 4) for the reception of these species the new genus *Miomastodon* which he defined as below. The genotypic species *Mastodon merriami* from the Middle Miocene, Virgin Valley formation, of Nevada, is the only specimen in which the incisive tusks were found in association with the grinding teeth, thus constituting an excellent type.

The rarity of the true mastodonts in Eurasia and America is attributable to their forest-living habits; they occur rarely in Austria, as recently described by Schlesinger of Vienna. The *Mastodon merriami* of Nevada, as it proves to be of Middle Miocene age, demonstrates that these true mastodonts came to America much earlier than we have hitherto been led to suppose. Middle Miocene age is quite consistent with the structure of the superior incisive tusks, which in *M. merriami* bear a broad enamel band on a *concave* external surface, whereas Schlesinger describes the Lower Pliocene mastodont *M. tapiroides americanus* as bearing an enamel band on a *convex* outer surface. We should expect the early true mastodonts to show just the progressive differences in the curvature and enamel of the tusks which these two observations would indicate. The species *Mastodon merriami* from the Middle Miocene of Nevada is apparently much more primitive than the species *Mastodon matthewi* from the Pliocene of the Snake Creek formation of Nebraska.

Osborn, 1922.—Osborn's formal description of the genus *Miomastodon* was as follows (Osborn, 1922.564, p. 4):

Miomastodon, new genus

Genotypic Species.—*Mastodon merriami* Osborn, 1921 . . . from the Virgin Valley formation, Middle Miocene of Nevada.

Generic Characters.—A member of the true Mastodontinæ phylum leading into the *Mastodon americanus* type, distinguished from the true *Palæomastodon beadnelli* of the Lower Oligocene of the Fayûm, Egypt, by rounded, greatly enlarged, upcurved superior tusks; form of inferior tusks not certainly known, probably rounded and more or less encased in enamel; distinguished from the true Pleistocene *Mastodon americanus* by the presence of a broad enamel band extending from the base to the summit of the tusk. Ridge formula: M 2 $\frac{3}{3}$, M 3 $\frac{3\ 1/2}{4}$, as compared with the *Palæomastodon beadnelli* ridge formula: M 2 $\frac{2\ 1/2}{3}$, M 3 $\frac{2\ 1/2}{3}$; as compared with the *Mastodon americanus* ridge formula: M 2 $\frac{3}{3}$, M 3 $\frac{4}{4\ 1/2}$.

To this genus may at present be referred four species, namely:

Genotypic species, *Mastodon merriami*, Middle Miocene, Nevada = *Miomastodon merriami*.

Mastodon proavus Cope, 1873, late Middle Miocene, Pawnee Creek, Colorado = *Miomastodon proavus* [subsequently referred by the present author to *Serridentinus*].

Mastodon matthewi Osborn, 1921, Middle Pliocene, western Nebraska = *Miomastodon matthewi* [now *Pliomastodon matthewi*].

Also probably *Mastodon tapiroides americanus* Schlesinger, Lower Pliocene of Hungary = *Miomastodon tapiroides americanus*.

The distinctive grinding tooth characters in all these Mastodontinæ are: (1) that each loph (protoloph, metaloph, *et seq.*) is composed of a main internal and external bunoid cone; (2) the intermediate conule region does not develop; (3) the earliest grinder is tetrabunodont; (4) as the third loph is added it becomes hexabunodont; (5) as the fourth loph is added it becomes octabunodont; (6) whereas these four, six, and eight cones heighten (hypsodonty), they never unite transversely into a crest; thus none of the Mastodontinæ becomes [truly] zygolophodont.

The broad enamel band of the tusks is apparently placed on the *concave* surface of the tusk in *Miomastodon merriami*, on the *convex* surface of the tusk in *Miomastodon tapiroides americanus*.

Middle Pliocene of Hungary.—In his Memoir of 1922 Schlesinger figures (Taf. XIV-XIX) and describes (pp. 115, 116, 227–230) a number of beautifully preserved upper and lower grinders under the name *M.* (*Mammut*) *americanus* Pennant *forma practypica* from the Palæontological Collections of Budapest. Unlike the previously

mentioned *Mastodon tapiroides americanus* of Lower Pliocene age, these teeth are regarded as of "Levantin" or Middle Pliocene age preceding that of *Mastodon* [*Anancus*] *arvernensis*. Consequently the species *M. praetypica* is geologically the most recent of all the specific stages heretofore described.

Through our present knowledge, therefore, there are five species known in Europe and in North America, in descending geologic order as follows:

1919–1922	*Mastodon americanus praetypica* Schlesinger, Hungary, of "Levantin" or Middle Pliocene age (*fide* Schlesinger)	= *Pliomastodon americanus praetypica*
1921	*Mastodon tapiroides americanus* (Schlesinger in Osborn), Hungary, of Lower Pliocene age (*fide* Schlesinger)	= *Miomastodon tapiroides americanus*
1921	*Mastodon matthewi* Osborn, Lower Pliocene, Snake Creek formation, western Nebraska (*fide* Matthew)	= *Pliomastodon matthewi*
1921	*Mastodon merriami* Osborn, Middle Miocene, Humboldt County, Nevada, Virgin Valley formation (*fide* Merriam)	= *Miomastodon merriami*
1933	*Miomastodon merriami* ref., Middle Miocene, Pawnee Creek, Colorado	= *Miomastodon merriami* ref.
1935	*Miomastodon depereti* sp. nov., Lower Miocene, Sables de l'Orléanais, France	= *Miomastodon depereti* sp. nov.

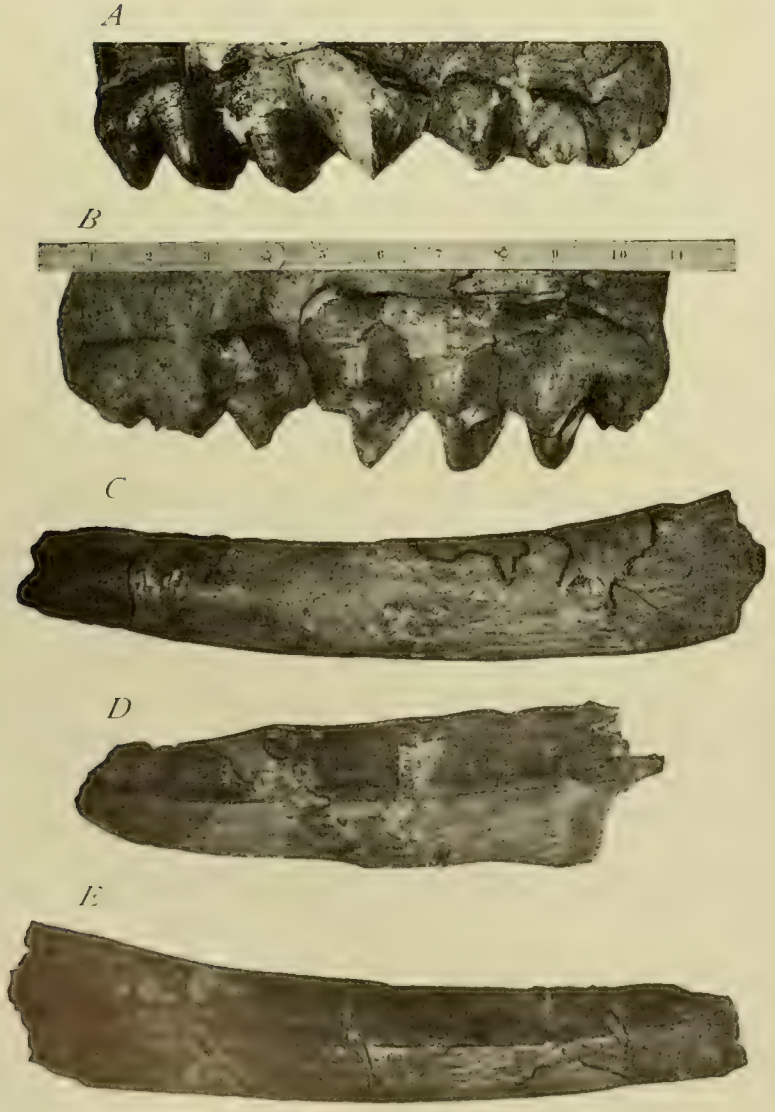
Miomastodon merriami Osborn, 1921

Figures 89, 98, B, 99

Virgin Valley formation, Middle Miocene, Thousand Creek, Humboldt County, Nevada; also Pawnee Creek, Colorado.

Mastodon merriami Osborn, 1921. "First Appearance of the True Mastodon in America," Amer. Mus. Novitates, No. 10, June 15, 1921, pp. 4–6 (Osborn, 1921.522). TYPE.—(Osborn, *op. cit.*, pp. 4–6). "The type specimens include several bone fragments, portions of the two upper tusks, and parts of the upper molars, in addition to the well-preserved two lower molars here figured as the type. A very important character is the presence of broad enamel bands on the upper tusks (Fig. 2, C, D, E), which are perhaps similar to the enamel bands observed by Schlesinger in the true Miocene and Pliocene mastodons of Hungary. . . . Type: Colo. Mus. 92, found in 1909 in the Thousand Creek formation [Virgin Valley formation], Humboldt County, Nevada, includes two left [now identified as left and right] inferior molars (Fig. 2, A, B [Fig. 1,B]; cast Amer. Mus. 14471, also portions of two upper tusks [and two superior molars]." TYPE FIGURE.—Osborn, 1921.522, fig. 1 ,B, p. 3, and fig. 2, p. 5 (Figs. 89, 98, and 99 of the present Memoir).

TYPE DESCRIPTION (OSBORN, 1921.522, P. 6).—"The contours of these grinding teeth, as seen from above (Fig. 1, B), are convexo-(inner side) concave (outer side); the first crest is relatively narrow; the second, third, and fourth crests are relatively broad; the rudimentary fifth crest is little if any more advanced than in *M. matthewi;* crests two to four exhibit rudimentary intermediate cones and the spurs of a trefoil. The presence of an enamel band on the tusks and the somewhat more brachyodont character of the grinding teeth separate this stage from the *M. americanus* (Fig. 1,



TYPE OF MIOMASTODON MERRIAMI

Fig. 99. Type superior molars and tusks of *Miomastodon merriami* Osborn, 1921 (Colo. Mus. 92), Virgin Valley formation, Middle Miocene, Nevada. See also figure 98,B. After Osborn, 1921.522, p. 5, fig. 2. About one-third natural size. Cast Amer. Mus. 14471.

A, Two superior grinding teeth, M^2, M^3, of the right maxilla, internal view. *B*, Same teeth, external view, with 11-inch scale indicated. *C*, Superior tusk of the left side, lateral view. *E*, External view of the same tusk. *D*, Superior tusk of the right side, external view. The presence of a broad enamel band on the concave outer surfaces of the right and left superior tusks is clearly indicated in *D* and *E*.

C) of the Pleistocene. This species is dedicated to Professor John C. Merriam, in recognition of his pioneer work in describing the fauna of Thousand Creek."

Miocene Type Locality.—The assignment of the type specimen to the Middle Pliocene of the Thousand Creek formation, Humboldt County, Nevada, was erroneous; this error was repeated by the writer in his paper of September 1, 1921 (Osborn 1921.526, p. 332), but was corrected in the following footnote in the same publication: "Immediately after the publication of this paper the author learned [from Prof. John C. Merriam] that the type of *Mastodon merriami* occurred in beds of Middle Miocene age, which makes it geologically older than *Mastodon matthewi*." (Letter, Merriam, June 24, 1921): . . . "I appreciate your courtesy in naming the Virgin Valley species in my honor. . . . I note that *Mastodon merriami* is referred to the Thousand Creek formation. The [type] locality described by Mr. Hills, namely, that at which G. D. Mathewson secured his material, is, however, summer of 1909 I went to Thousand Creek to examine the occurrence near there of precious opal. . . . I continued the journey to Denio, Oregon. The following morning I left for a ranch on Thousand Creek. At the ranch I found specimens of the opal and fragments of a Mastodon tooth which my guide, George D. Mathewson, said he had found in digging one of the excavations along the opal outcrop. This outcrop is situated on a precipitous hill about 500 feet above the level of [the stream known as] Thousand Creek and between the main forks of the creek. . . . Mr. Mathewson had already dug out most of the bone fragments and thrown them out on the side of the excavation. I dug out a few remaining fragments myself and went very carefully over all the stuff that had been excavated and thrown out. Sifting was out of the question at that time as the ash was so wet as to form a stiff mud. I placed all the fragments, including the tusks, into a sack which was carried down to the ranch and later packed into a box for transportation on the stage 130 miles to the railroad and thence

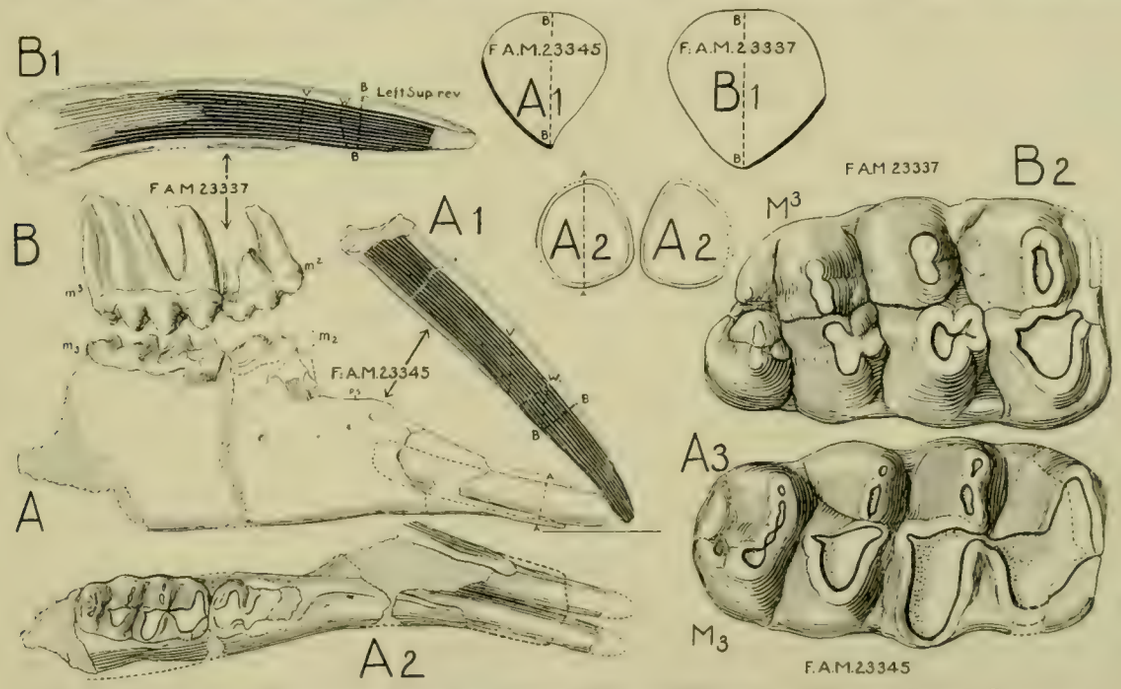


Fig. 100. Referred Miomastodon merriami Osborn, Middle Miocene of Pawnee Creek, Colorado
Modified after Frick, 1933, Figs. 28, 24

Jaw with tusk (F:A.M. 23345), one-eighth natural size. Molars (F:A.M. 23345, 23337), one-third natural size.

A–A3, Mandible with second and third molars, also inferior and superior tusks and sections (F:A.M. 23345). This appears to be a typical *Miomastodon*.

B–B2, Superior molar and tusk, also section, of another individual (F:A.M. 23337). This third superior molar, M^3, differs from the typical *Miomastodon* molar with trefoils.

in the Virgin Valley formation, which is of approximately Middle Miocene age, not far from the zone of the Mascall of the John Day region. . . . this evidently brings the appearance of these Mastodons back to near Middle Miocene."

Osborn corrected this geologic error specifically in *Science* (Osborn, 1921.523, p. 108).

The Colorado Museum record of this specimen is (letter, Figgins, February 25, 1921): "No. 92: from the John Day formation (Miocene), Thousand Isle Creek, Humboldt county, Nevada, found April, 1909, by Geo. D. Mathewson, Denio, Ore." Mr. Richard C. Hills writes (letter, March 9, 1921): "Early in the by express to Denver. The parts must all belong to one individual. I spent considerable time in assembling the fragments. In addition to the two lower molars, there are parts of the upper molars on one side embedded in a portion of the upper jaw. The tusks are not entire. You can, however, see the black enamel bands in the photographs. We can, if you so desire, furnish other photographs showing the upper molars."

Osborn, 1922: The writer is greatly indebted to Director Figgins, also to the geologist, Richard C. Hills for the privilege of examining and describing this most important specimen which demonstrates the arrival of a member of the true Mastodontinæ

phylum in the Nevada region of America in Middle Miocene time. The presence of a broad enamel band on the upper tusks is a very important character; these enamel bands are perhaps similar to the enamel bands observed by Schlesinger in some of the true Lower Pliocene mastodons of Hungary (as recorded in his published Memoir) to which he has assigned the name *Mastodon tapiroides americanus*. A significant difference is that in *Miomastodon merriami* the enamel is on the outer *concave* surface of the tusk, whereas in the photographs of *M. tapiroides americanus* furnished by Doctor Schlesinger the enamel is on the outer *convex* surface.

Miomastodon merriami of Colorado (Fig. 100).—These most welcome specimens (F:A.M. 23345, 23337), discovered by the Frick Expedition of 1932 in the classic Pawnee Creek horizon of Colorado, were referred by Frick (1933, p. 611, fig. 28) to '*Miomastodon proavus* Cope.' They constitute a most timely and important addition to our knowledge of the Middle Miocene genus *Miomastodon* and greatly strengthen Osborn's theory of the year 1921 that *Miomastodon merriami* represents the arrival of ancestors of the true Mastodontinæ in America in Middle Miocene time.

The specific reference (Frick, 1933) of these specimens to the Pawnee Creek type of '*Mastodon*' *proavus* Cope was an error, because the two fragmentary grinding teeth of *M. proavus* (see Chap. X, fig. 363) clearly exhibit the characteristic serrate spur on both sides of the ectoconelet, both in the premolar and the fragmentary molar, also the reduction of the contiguous mesoconelet; these two features are highly characteristic of the Serridentinæ, as pointed out in Chapter X, pages 403, 404, where a detailed description with figures of *Serridentinus proavus* is given. In the lower grinders of *Miomastodon merriami*, on the contrary (see especially Fig. 98B, type lower grinders of Amer. Mus. 14471), there is no serration on the sides of the ectoconelet, but there is a distinct trefoil expansion of the contiguous mesoconelet.

The expanded trefoils on the ectoconelets[1] of the Mastodontinæ become more conspicuous as the teeth are worn down, as shown in the much worn r.M_3 of F:A.M. 23345 of the Pawnee Creek (Fig. 100). This *mesial expansion* of the ectoconelet is also observed in *Miomastodon tapiroides* Schles. (Fig. 98 D1), in *Pliomastodon matthewi* (Figs. 98 A2 and 102), as well as in certain specimens of *Mastodon americanus* (Fig. 89—Amer. Mus. 14293, r.M^3, Amer. Mus. 14294, r.M_3); this *mesial expansion* is therefore characteristic of the phylum Mastodontinæ.

The comparative measurements are as follows:

	ap.	tr.	I.
Type (Colo. Mus. 92):			
R.M_3	179	80	45
Referred (F:A.M. 23345):			
R.M_3	164	77	47
Incisive tusk (upper)			
Length			450 mm.
Vertical diameter			67
Transverse diameter			56
Width of enamel band			49
Incisive tusk (lower)			
Length			250+
Vertical diameter			40
Transverse diameter			35

New generic and specific characters revealed (Fig. 100) in the Pawnee Creek specimens are: (1) *Mesial expansion* of rudimentary trefoils in ento- and ectoconelets, upper and lower; (2) mandibular rostrum laterally compressed, abbreviate as compared with *Trilophodon* or *Serridentinus;* (3) rodlike inferior incisors, vertical oval section; (4) downturned superior incisors of moderate length, broad enamel band, broadly oval vertical section.

Miomastodon tapiroides americanus Schlesinger, 1921, 1922

Figure 98

Lower Pliocene, Tasnád, Usztató Komitat, Hungary.

Mastodon tapiroides americanus Schlesinger (in Osborn). "First Appearance of the True Mastodon in America," Amer. Mus. Novitates, No. 10, June 15, 1921, p. 2. Schlesinger's description: "Die Mastodonten der Budapester Sammlungen," 1922, Geol. Hungarica, II, Fasc. 1, pp. 224–227, Taf. xiii, figs. 6, 7, and xiv, figs. 1–4. Type.—A third left superior molar, l.M^3, also two left inferior molars, l.M_{2-3}. Horizon and Locality.—Lower Pliocene, Tasnád, Usztató Kom., Hungary. Type Figure.—*Op. cit.*, Osborn, 1921.522, p. 3, fig. 1, D, D1 (see Fig. 98D, D1 of the present Memoir).

Type Description.—(*Op. cit.*, Osborn, 1921.522, p. 2): "There cannot be the least doubt, however, as to the affinity [to the true Mastodon] of the grinding teeth found in the Lower Pliocene of Hungary, to which Schlesinger applies the name *M. tapiroides americanus*. These [type] teeth are reproduced [redrawn] herewith (Fig. 1, D, D1) from unpublished photographs, kindly forwarded by the author, to the same scale with corresponding grinders (A, ... A2, A3) from the Lower Pliocene, Snake Creek formation, of western Nebraska, also with lower teeth (B) from the Middle Pliocene [Middle Miocene, Virgin Valley formation], [near] Thousand Creek, Nevada, and with (C) the posterior lower molar of *M. americanus* from the American Pleistocene."

"The upper and lower grinders from the Lower Pliocene, Tasnád, Usztató Kom., Hungary, embrace a third left superior molar (Fig. 1, D1, see Pl. xiii, fig. 5 [error H. F. O.], Schlesinger), also two left inferior molars, m_2-m_3 (Fig. 1, D, see Pl. xiv, fig. 1, Schlesinger). The linear measurement of the crowns agrees closely with that of the Pleistocene *M. americanus*, but the vertical measurement is apparently less, i.e., less hypsodont. This indicates that already in the Lower Pliocene the mastodonts had attained the massive proportions of their Pleistocene descendants. The lophs are similarly composed and show no trace of a trefoil ridge. There is nothing to debar these Lower Pliocene mastodonts of Hungary from the true ancestral line of our Pleistocene *Mastodon*."

Osborn, 1925: Since the above type description was written for Doctor Schlesinger the species has been transferred to the genus *Miomastodon*. The incisive tusks discovered in the same locality and probably attributable to the same species appear in the photographs furnished by Doctor Schlesinger to bear a broad enamel band on the *convex* external surface; if this determination is correct, it would seem that in these Pliocene mastodonts the tusks are outwardly convex, as in *Mastodon americanus*, a progressive character; as observed in *Miomastodon merriami*, the tusks are outwardly concave.

[1]Unworn molars of the Mastodontinae clearly demonstrate that the rudimentary trefoil spur springs from the *ectoconelets* in the inferior molars, from the *entoconelets* in the superior molars. The worn molar gives a false impression that the trefoil spurs arise from the mesoconelets.

8. CHARACTERS OF PLIOMASTODON AND ITS INCLUDED SPECIES

SUBFAMILY: MASTODONTINÆ Brandt, 1869—Osborn, 1910

GENUS: **PLIOMASTODON** Osborn, 1926

Original reference: Amer. Mus. Novitates, No. 238, Nov. 30, 1926, p. 1 (Osborn, 1926.706)

GENERIC CHARACTERS.—Incisive tusks with enamel band vestigial or wanting, suboval to rounded in section, upturned (*P. vexillarius*); ridge-crests with expanded ectotrefoils (*P. matthewi*); intermediate in hypsodonty between *Miomastodon* and *Mastodon*.

Mastodon (*Miomastodon*) *matthewi*, the genotypic species of *Pliomastodon*, is of Lower Pliocene age, whereas *Mastodon merriami*, the genotypic species of *Miomastodon*, is of Middle Miocene age. In the superior incisive tusks of *Pliomastodon* (genotype) the lateral enamel band is *absent;* in the superior incisive tusks of *Miomastodon* the lateral enamel band is present. Both of these generic stages are imperfectly known at present.

This Pliocene stage is based on the species first described by Osborn as *Mastodon matthewi* (Osborn, 1921.522, pp. 2, 4), then as *Miomastodon matthewi* (Osborn, 1922.564, p. 4), and finally made the genotype of the genus *Pliomastodon* (Osborn, 1926.706). This generic stage (Fig. 98) is typified by a right third superior molar, r.M^3 (Amer. Mus. 18237), and by paratypes r.M_3 (Amer. Mus. 18238) and r.M_1 (Amer. Mus. 18239), also by a referred r.M_3 (Amer. Mus. 19248*a*) and a referred tusk (Amer. Mus. 19248*b*) all from the Snake Creek B formation of western Nebraska, quarries 1 and 5, as shown in the table (Chap. X, p. 427). Associated with these specimens of *Pliomastodon* were the type and referred specimens of *Serridentinus anguirivalis*, *S. nebrascensis*, and *Rhynchotherium anguirivalis*.

AMERICAN PLIOCENE SERRIDENTINUS AND MASTODON.—During the summer of 1908 an American Museum party under W. D. Matthew and Harold J. Cook first collected in the "Lower Pliocene" deposits of western Nebraska, subsequently known as the Snake Creek beds (Matthew and Cook, 1909, p. 363). The first proboscidean molars discovered belonged to the serrated molar group and are now referred to *Serridentinus anguirivalis*.

Subsequently, in the seasons of 1916 and 1918, several bunolophodont grinders (Amer. Mus. 18237, 18238, 18239, and 17217) were also discovered in the same Snake Creek formation; three years later, under the title "First Appearance of the True Mastodon in America" (Osborn, 1921.522, pp. 2, 4), Osborn selected these specimens (Fig. 98 A-A3) as the type and paratypes of a new species which he named *Mastodon matthewi*, in honor of Dr. W. D. Matthew the author who first described the new and interesting fauna of the Snake Creek formation. Amer. Mus. 17217, however, was erroneously figured as a paratype of *Mastodon matthewi* and has since been made the type of *Serridentinus anguirivalis* Osborn, 1926. The reader is referred to the new figures of the type, paratypes, and referred specimens of *Pliomastodon matthewi* from the Snake Creek B level (Fig. 102), a description of which species follows.

Pliomastodon matthewi Osborn, 1921–1926

Figures 89, 98, 101, 102

Snake Creek formation, Lower Pliocene, level B, Sioux County, western Nebraska. Collected by the American Museum expeditions of 1916 and 1918.

Mastodon matthewi Osborn, 1921. "First Appearance of the True Mastodon in America," Amer. Mus. Novitates, No. 10, June 15, 1921, pp. 2–6 (Osborn, 1921.522).

Miomastodon matthewi Osborn, 1922. "*Dibelodon edensis* (Frick) of Southern California, *Miomastodon* of the Middle Miocene, New Genus." Amer. Mus. Novitates, No. 49, Oct. 23, 1922, p. 4 (Osborn, 1922. 564).

Pliomastodon matthewi Osborn, 1926. "Additional New Genera and Species of the Mastodontoid Proboscidea." Amer. Mus. Novitates, No. 238, Nov. 30, 1926, p. 1 (Osborn, 1926.706).

TYPE DESCRIPTION AND TYPE LOCALITY.—(Osborn, 1921.522, p. 2): . . . "Subsequently, in 1918, several distinctive specimens were found in the same beds which may now be named as the type and paratypes of a new species of *Mastodon* (*Mastodon matthewi*),

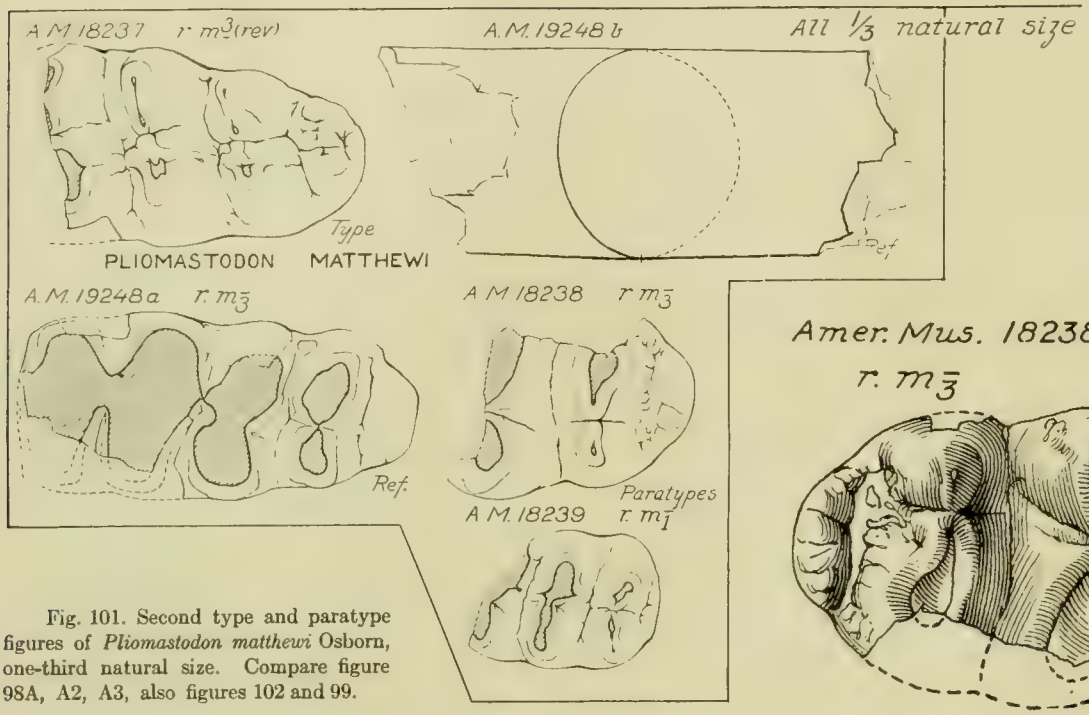
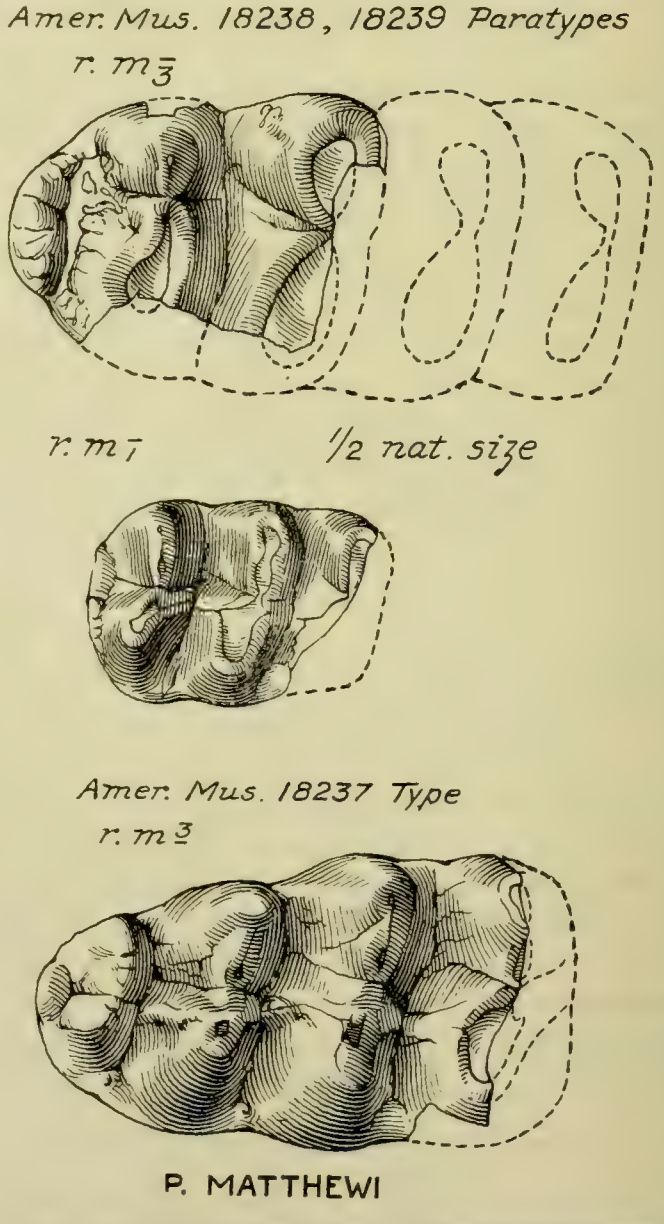


Fig. 101. Second type and paratype figures of *Pliomastodon matthewi* Osborn, one-third natural size. Compare figure 98A, A2, A3, also figures 102 and 99.

in honor of Dr. W. D. Matthew, the author who first described this interesting fauna. . . . [p. 4] TYPE: the right third superior molar, Amer. Mus. 18237. PARATYPES: the right second inferior [superior] molar (unworn), Amer. Mus. 17217[1] [this tooth has now been made the type of *Serridentinus anguirivalis*]; the posterior portion of a right third inferior molar (more worn), Amer. Mus. 18238, also of a right second [first] inferior molar, Amer. Mus. 18239. The type and paratypes probably belong to four different individuals. . . . The type and Nos. 18238 and 18239 are from the Snake Creek B level (*Procamelus-Hipparion* Zone) of Sioux County, Nebraska; the level of No. 17217 is not recorded. The type (Fig. 1, A) is distinguished by the rapid narrowing of the posterior half of the crown of the third upper molar, including the third and fourth crests; the fourth crest is extremely narrow and bilobed; the rudimentary fifth crest consists of a single cusp. In these features *M. matthewi* is more primitive than the corresponding tooth of *M. tapiroides americanus* (Fig. 1, D1) of the Lower Pliocene of Hungary. The association of the lower molars, Amer. Mus. 17217 [error H. F. O.], 18238, 18239, as paratypes is provisional, because the Snake Creek deposition extended over a long period of time and may represent more than two life zones. Of these teeth, [m^2] presents three unworn pointed crests with the rudiments of a trefoil (Fig. 1, A1[1]); in a second [first] molar (. . . A2) the trefoil is less apparent; in the third lower molar (. . . A3) it is not apparent at all. In the latter tooth, which is probably the posterior half of a third lower molar of the right side, the third and fourth crests are partly preserved; crest five is represented by a broad tuberculate talon." Compare figure 98 of the present Memoir.

SPECIFIC CHARACTERS (FIG. 102).—As compared with the type molars of *Miomastodon merriami* (Fig. 98, B), the type and paratype molars of *Pliomastodon matthewi* (Fig. 98, A, A2, A3,

[1]See Chap. X, fig. 391, p. 425.



THIRD TYPE AND PARATYPE FIGURES OF PLIOMASTODON MATTHEWI

Fig. 102. Type and paratypes of *Pliomastodon matthewi*, Snake Creek B horizon (upper), western Nebraska, one-half natural size. Type (Amer. Mus. 18237), a right third superior molar, r.M^3. Paratypes (Amer. Mus. 18238), a right third inferior molar, r.M_3, partly restored; (Amer. Mus. 18239), a right first inferior molar, r.M_1. For comparison with other mastodonts of Snake Creek, see figure 394.

and Fig. 102) show a greater elevation (subhypsodonty) and a greater anteroposterior compression (lophodonty). The summits of the paired lobes, i.e., cones, seem to be somewhat more approximated. Another distinctive feature is the posterior narrowing of the crown of the third superior molar (Fig. 98, A and Fig. 102).

Since the original description and figures were prepared (Fig. 98), another molar tooth (Amer. Mus. 19248*a*), collected in 1918, has been identified as a third inferior molar of the right side, r.M_3. In the same quarry (Quarry 5) was found a section of a superior incisive tusk (Amer. Mus. 19248*b*) somewhat abraded by river erosion, which shows no sign of the superior enamel band. These two specimens have been mentioned as indicating a more recent geologic age and with correspondingly progressive characters which signalize a new generic stage for which the name *Pliomastodon* (see Osborn, 1926.706, p. 1) seems appropriate (Fig. 101).

Comparative Measurements	*Miomastodon merriami* Type	*Pliomastodon matthewi* Type and Ref.
Third superior molar, M^3, anteroposterior	154e	160
Height of internal cone of metaloph	60e	57 (type)
Third inferior molar, M_3, anteroposterior	179	194
transverse	80	
breadth-length index	45	
Height of internal cone of metalophid	54e	61e
Superior incisive tusk, I^2 Vertical diameter	92e	90
Transverse diameter		81

The progressive development of the molar crowns in these respective Miocene and Pliocene species may also be carefully examined and compared from the following figures:

Pliomastodon matthewi. Figure 98, A, A2, A3, original type and paratype figures; figure 89, type and paratypes in comparison with *Miomastodon merriami*, *Pliomastodon americanus praetypica*, *Mastodon americanus*, and *Palæomastodon intermedius;* figure 394, new type and paratype figures in comparison with other Snake Creek B mastodonts; figures 102 and 101, new type and paratype figures.

Miomastodon merriami. Figure 99, type superior molars and tusks; figure 98, type molars in comparison with *Pliomastodon matthewi*, *Mastodon tapiroides*, and *M. americanus;* figure 89, type molars in comparison with *Pliomastodon matthewi*, *P. americanus praetypica*, *M. americanus*, and *Palæomastodon intermedius.*

The above comparative measurements and figures reveal that in both *Miomastodon merriami* and *Pliomastodon matthewi* the crowns of the superior and inferior third molars, M^3 and M_3, *narrow posteriorly*, the tetartoloph and -lophid have not attained the width seen in *Mastodon americanus*, the pentaloph and -lophid are very rudimentary, whereas in *Pliomastodon americanus praetypica* the pentalophid is almost as strong as in *M. americanus.* The distinction between *Miomastodon merriami* and *Pliomastodon matthewi* is partly seen in the height of the crowns, the lophs in *M. merriami* (e.g., Fig. 98, B) being somewhat less elevated than in *P. matthewi* (e.g., Fig. 98, A). The progressive difference is not so well marked in the grinding teeth as it is in the tusks, as observed by comparison of the type of *M. merriami* (Fig. 99) and new type figure of *P. matthewi* (Fig. 102).

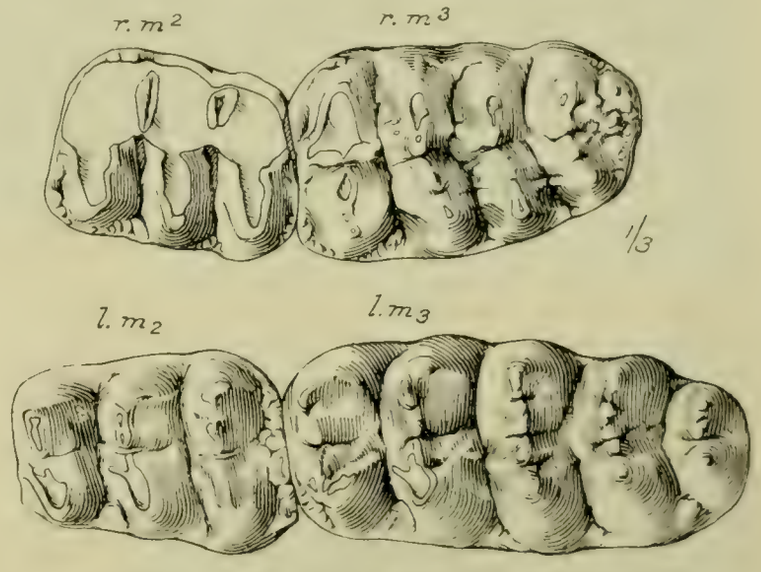
Pliomastodon americanus praetypica
Schlesinger, 1919, 1922

Figures 89, 103, and Pl. I, pp. 134–135

Upper(?) Pontian and Levantin age, Middle Pliocene. Batta-Érd, Rákoskeresztúr, Szentlörincz, and Ajnácskö, Hungary.

Schlesinger originally described this true species of *Mastodon* from Hungary in his paper of 1919, as cited below, figuring his excellent types in Taf. VI, figs. 2–4. His final and more complete description appears in his Memoir of 1922.

Mastodon (Mammut) americanus Penn. *forma praetypica* Schlesinger, 1919. "Die stratigraphische Bedeutung der europäischen Mastodonten," Mitt. Geol. Ges. Wien, XI, p. 142.



Cotypes of Pliomastodon americanus praetypica

Fig. 103. Cotypes of *Mastodon (Mammut) americanus* Penn. *forma praetypica* Schlesinger selected in the present Memoir, namely, second and third right superior molars, r.M^{2-3}, and second and third left inferior molars, l.M_{2-3}, one-third natural size. Compare Schlesinger, 1922, Taf. XV, figs. 2 and 4. Originals in Hungarian National Museum, Budapest.

Right superior molars, r.M^{2-3}: Szabadka (=Maria-Theresiopel), Komitat Pest, Hungary.

Left inferior molars, l.M_{2-3}: Batta-Érd, Komitat Pest, Hungary.

Original Description.—Schlesinger, 1919, p. 142): "a) Die intermediären Molaren (vgl. Tafel VI, Figur 2–4) dieser, früher mit *M. Borsoni* zusammengeworfenen Spezies, schliessen sich im Bau engstens an die vorbesprochene Art an, nur sind die Kronen breiter, die Täler enger. b) Für die letzten Molaren (vgl. Tafel VI, Figur 1, 3, 4) gilt, abgesehen von der höheren Jochformel (4× im Ober-, 4×—5 im Unterkiefer) das gleiche. Hier tritt meist noch das Merkmal der geringeren und etwas anderen Ausbildung der Sperrleisten helfend dazu. Trotzdem ist die Bestimmung schwierig und ohne breitere Vergleichsbasis die Trennung von der miozänen Form oft unmöglich."

M. [*Mastodon*] (*Mammut*) *americanus* Pennant *forma praetypica n.f.*, 1922. "Die Mastodonten der Budapester Sammlungen." Geol. Hungarica, Ed. Sep., Tome II, Fasc. 1, pp. 115, 116, 227–230.

Cotypes.—The cotypes selected for illustration in this Memoir are the second and third superior and inferior molars from two localities, as follows (Schlesinger, 1922, Taf. xv, figs. 2 and 4—same as Figs. 3*a* and 4 of Schlesinger, 1919, Taf. vi, on larger scale): "Figur 2: M^{2-3} *dext.* von der Kaufläche [Szabadka (=Maria-Theresiopel), (Kom. Pest). Levantin]. . . . Figur 4: Linke Mandibel mit M_{2+3}. *Fundort:* Batta-Érd, Komitat Pest. *Horizont:* Oberstes Pontikum (Unterpliozän). Wiedergabe aller vier Figuren: ½ natürl. Gr." Originals of figures 1 and 3 in the Hungarian National Museum of Budapest; of figures 2 and 4 in the Hungarian Reichsanstalt of Budapest. Cotype Localities.—Aside from Batta-Érd, Schlesinger mentions three other cotype localities, namely, Rákoskeresztúr, Szentlörincz, and Ajnácskö, Hungary. Upper(?) Pontian or Levantine age, (?)Middle Pliocene. Cotype Figures.—Schlesinger, 1922, Taf. xiv-xix. These enlarged cotype figures include the original figures of Schlesinger, 1919, Taf. vi, figs. 2–4.

Comparison with Mastodon americanus.—Schlesinger, 1922, "Die Mastodonten der Budapester Sammlungen," illustrates a large number of grinding teeth of the true *Mastodon americanus* in the collections of Budapest and of Vienna (*op. cit.*, 1922, Taf. xv-xxii) from different localities in the United States, and compares in great detail the grinding tooth characteristics of *Mastodon americanus typica* with the grinding tooth characteristics of *M. americanus praetypica* and of *M.* [*Zygolophodon*] *borsoni*. He also summarizes in several parts of his invaluable Memoir of 1922 the resemblances and differences between the *Mastodon americanus* and the *M.* [*Z.*] *borsoni* phyla.

Geographic Distribution of Pliomastodon americanus praetypica.—The cotypes selected in this Memoir (Fig. 103) are from Batta-Érd and Szabadka (=Maria Theresiopel), Komitat Pest, Hungary; Schlesinger mentions three other cotype localities, namely, Rákoskeresztúr, Szentlörincz, and Ajnácskö. (Schlesinger, 1922, p. 229): "Die Zahl der gut horizontierten Fundpunkte des *M. americanus f. praetypica* ist zwar nicht reichlich, doch sind es qualitativ hochwertige Stellen. An dreien von ihnen (Rákos, Szentlörincz und Batta-Érd) ist eine konkordante Aufeinanderfolge oberpontischer und levantiner Bildungen erwiesen; in allen Fällen kamen die Reste von *M. americanus f. praetypica* aus dem mittelpliozänen Niveau." (*Op. cit.*, p. 230): "Solche Belege können bei der Beurteilung einer Frage natürlich nicht übergangen werden. Ich bin vielmehr der festen Überzeugung, dass *M. americanus f. praetypica* mit dem Ende des Levantins aus unserem Gebiete endgiltig abgewandert ist."

Osborn, 1926: In his volume of 1922, Taf. xiv–xix, Schlesinger figures numerous beautifully preserved upper and lower teeth from the Pliocene of Hungary which he refers to *Mastodon (Mammut) americanus forma praetypica*. As to the geologic age of these specimens, Schlesinger considers (*op. cit.*, p. 227) that undoubtedly they are of "Levantin age" similar to that of *M. arvernensis*, namely, Upper Pontian [?Middle Pliocene]. As to geographic distribution and migration, he remarks as quoted above.

We may consider as the cotypes the eight grinding teeth figured in Taf. xiv–xix of Doctor Schlesinger's Memoir.

Pliomastodon sellardsi Simpson, 1930

Figures 104, 105

Brewster, Florida; Lower Pliocene, Bone Valley formation.

The type of *Pliomastodon sellardsi* was first described (1916) by Dr. E. H. Sellards, at that time State Geologist of Florida, as referable to *Mammut progenium?* (see Sellards, 1916, p. 95, Pl. x). The author pointed out, however, its close resemblance to *Mastodon americanus* but emphasized the longer symphysis. The specimen was discovered in the mine of the American Cyanamid Company at Brewster and was sent to Doctor Sellards by the late Anton Schneider, then superintendent of the company. The right half of the mandible was returned to Mr. Schneider at his request and has since been mislaid, but the left half of the mandible is available at the Florida Geological Survey. Doctor Simpson in connection with his description gives three views of the specimen, the missing right mandible, internal and external aspects, also superior view of both sides, which are reproduced as figures 104 and 105 of the present Memoir.

Pliomastodon sellardsi Simpson, 1930. "Tertiary Land Mammals of Florida," Bull. Amer. Mus. Nat. Hist., LIX, Art. III, pp. 203–206. Type.—"Left lower jaw with M_{2-3}.

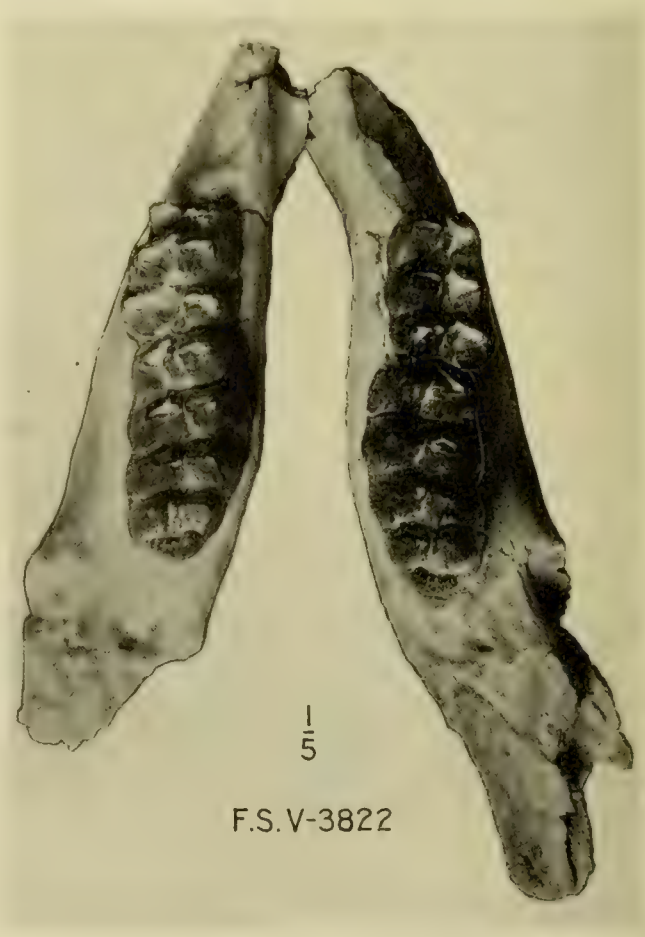


Fig. 104. *Pliomastodon sellardsi* Simpson, type (Fla. Geol. Surv. V3822), from Brewster, Florida. Lower jaw with right and left M_{2-3}, crown view. One-fifth natural size. After Simpson, 1930, fig. 30. Compare figure 87, *M. americanus*.

Right lower jaw of same individual known from photographs, present location unknown. Presented by Anton Schneider." Fla. Geol. Surv. V3822 (old number 6160). HORIZON AND LOCALITY.—"Lower Pliocene, Bone Valley Formation, pit of American Cyanamid Company, Brewster, Florida." TYPE FIGURE.—*Op. cit.*, fig. 30, p. 204, fig. 31, p. 205.

TYPE DESCRIPTION.—(Simpson, 1930, p. 203): "Symphysis elongate, stout lower tusks, alveoli about 50 mm. in diameter near posterior end. M_2 fully trilophodont. Fifth crest of M_3 less developed than in *Mastodon americanus*, ridge-like, more distinct internal cusp and four closely appressed cuspules external to it. Cusps more elevated than in *Miomastodon merriami*, less than [in] *Mastodon americanus*, about as in *Pliomastodon matthewi*. Inner side of M_3 strongly convex, outer border straight. First loph distinctly narrower than second, and last two lophs also relatively narrower than in *Mastodon*."

Measurements	
M_2 Length	110 mm.
Width	80
M_3 Length	164
Width (max.), second loph	95

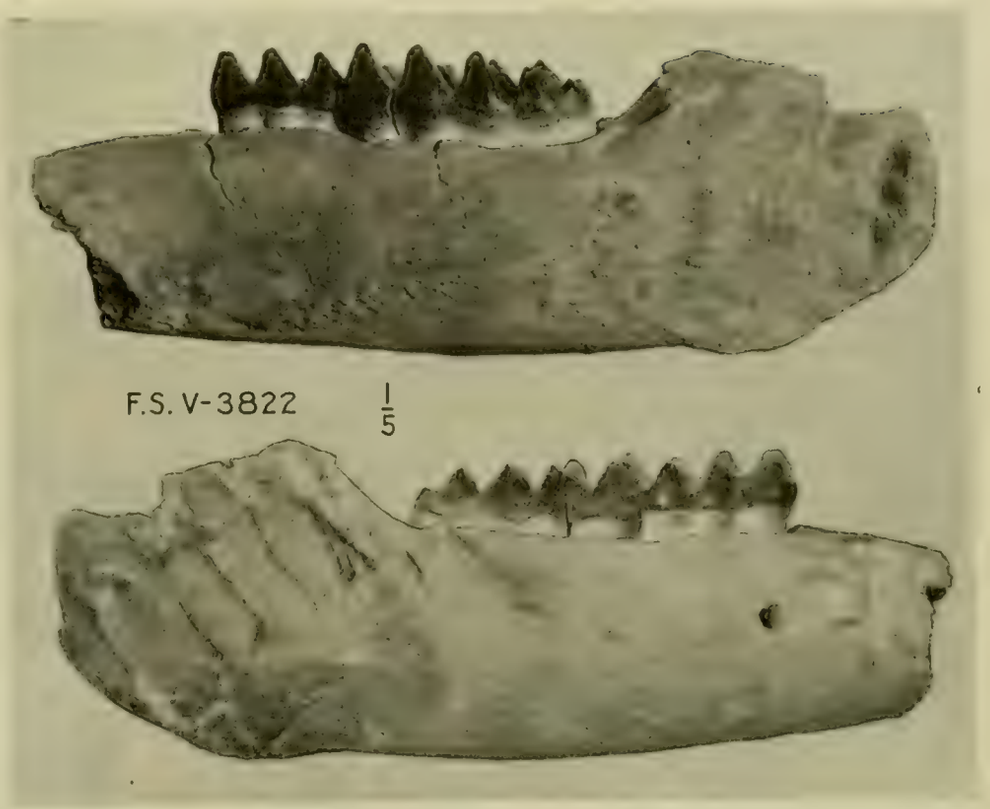


Fig. 105. *Pliomastodon sellardsi* Simpson. Missing part of type. Right lower jaw with M_{2-3}, internal and external views. One-fifth natural size. After Simpson, 1930, fig. 31.

Height internal cone of first crest—actual 55 mm., estimated 57 mm.

Height internal cone of second crest—actual 56 mm., estimated 59 mm.

Osborn, 1933: *Pliomastodon sellardsi*, according to the above descriptions of Sellards (1916) and of Simpson (1930), is a most welcome addition to the American ancestry of *Mastodon americanus;* it is distinguished by its longer rostrum, with ridge-crests intermediate between *Miomastodon merriami* and *Mastodon americanus.*

To the same species may be referred a right mandibular ramus (Fla. Geol. Surv., V-5376, cast Amer. Mus. 26979), with M_2, M_3; measurements of M_3 181×98 mm., index 54, found at a locality not very far from that of the type.

Pliomastodon vexillarius Matthew, 1930

Figures 106–108

From southeast of Coalinga, Fresno County, California. Upper Etchegoin [=late Pliocene]. *Plesippus proversus* life zone.

Faunal Level. (Stirton, August 8, 1932): "The type of *Pliomastodon vexillarius* was found in the upper portion of the Etchegoin section in the North Coalinga region. This section has been worked by Ralph Stewart (U. S. Geol. Surv.) who collected isolated teeth of *Plesippus proversus* and *Castor californicus* as his index fossils. Late Pliocene."

The Standard Oil Company of California, in excavating on its properties at the north end of the Kettleman Hills anticline, southeast of Coalinga, California, discovered the specimen described by Dr. W. D. Matthew as *Pliomastodon vexillarius*, the specific name signifying "standard bearer," chosen "in recognition of the very important contributions to paleontology made by the Standard Oil Company of California in the course of its operations and researches, and the care which the officers of the company have taken to preserve and turn over to scientific museums the collections made by their parties and to facilitate in many ways field studies and collecting work of this [University of California] and other institutions." Doctor Matthew states (p. 338) that "Whatever be the final determination as to nomenclature and taxonomic status, the skull represents a type of American mastodon hitherto known only from teeth and jaw fragments. It is distinguished from the long-jawed species by the short jaws and upward curving enamelless tusks, from the *mirificus* group by simple molars with little trefoil development, from the 'American Mastodon' by the shortened skull base with overhanging occiput and the marked approach to anteroposterior succession of teeth."

Pliomastodon vexillarius Matthew, 1930. "A Pliocene Mastodon Skull from California Pliomastodon vexillarius, N. Sp.," Bull. Dept. Geol. Univ. Calif., XIX, No. 16, pp. 335–348, Pls. XLI–XLIV, text. figs. 1, 2. TYPE.—Back of skull and palatal region approximately complete, zygomata broken but parts of them preserved, frontonasal and orbital regions partly preserved. Dentigerous portions of both sides of lower jaws complete, but of the symphysis, angles, and coronoid, little is left. Atlas complete, one femur, an astragalus, patella, and parts of other limb bones. Crowns of teeth largely missing; most of M^2,

right and left, and small parts of M^3, posterior halves of M_3, right and left, preserved, but only the bases of the crowns of the remainder of the second and third molars. First molars had been lost during life and their alveoli partly closed; second molars well worn, third molars unworn in the posterior half, probably lightly worn in front. Original in the Museum of Paleontology, University of California (No. 28301). Horizon and Locality.—North end of the Kettleman Hills anticline, southeast of Coalinga, Fresno County, California. Upper Etchegoin [=late Pliocene]. Type Figure.—*Op. cit.*, Pls. xli–xliv, text figs. 1 and 2.

Geologic Age.—(Matthew, *op. cit.*, p. 338): "The type and only known specimen of the genus is a last upper molar from the Snake Creek beds (referred by Matthew to *Zygolophodon* in 1918 [made by Osborn in 1921 the type of *Mastodon* (*Pliomastodon*) *matthewi*]) and owing to the crowns of the upper teeth being broken off in our skull, exact comparison is impossible. It agrees, however, in geological age, and the fauna of the Lower Etchegoin is largely composed of the same genera as the Snake Creek fauna, so that provisionally I refer the skull to *Pliomastodon*. As at present understood, it represents an advanced stage of the *Zygolophodon* phylum and might be regarded as a progressive species or subgenus of Vacek's genus or as a distinct genus, according to the relative weight given to one or another of the progressive characters."

Distinctive Generic Characters.—(Cf. Matthew, *op. cit.*, p. 336). Upper tusks large, cylindrical, close together and subparallel at base, curving gently upward and outward, a narrow strip of thin enamel showing at the base on the outer side but no clear evidence of enamel beyond the alveolus. Lower tusks probably absent. Molar teeth wide, moderately crested, less so than in *Mastodon*, trefoils single, not prominent, valleys open, M 2 trilophodont, M 3 with 4½ crests. The basicranial region of the skull is little elevated above palatal plane, much shortened as compared with *Mastodon*, occiput very low and wide, heavily overhanging backward instead of nearly vertical as in *Mastodon* and other genera. Posterior nares crowded forward so as to be opposite the back of M^3; in *Mastodon* they are considerably behind it. The entire basicranial region is thus crowded forward along with the condyles, which are scarcely over half as far behind the teeth as in *Mastodon*. This forward crowding is paralleled in some of the other mastodontines and in the elephants, but mostly with a much higher elevation, especially in the latter group, of the basicranial above the palatal plane. The author states that the skull apparently cannot be placed in any of the better known Mastodontine genera, and gives its distinguishing characters from *Gomphotherium*, "*Serridentinus*," *Mastodon*, *Cuvieronius*, *Anancus*, *Cordillerion*, *Tetralophodon*, *Pentalophodon*, *Rhynchotherium*, and *Choerolophodon*.

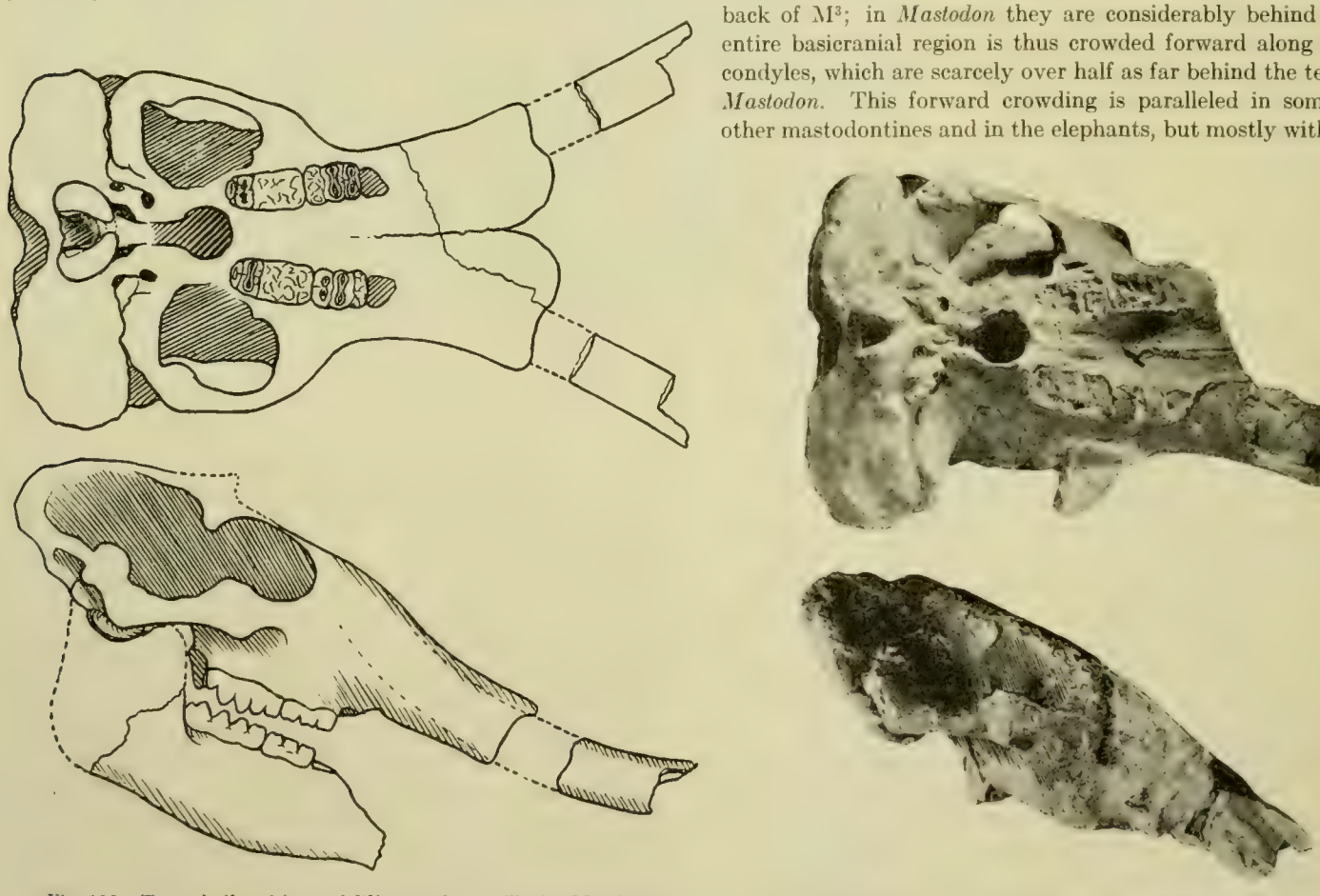


Fig. 106. Type skull and jaws of *Pliomastodon vexillarius* Matthew (Mus. Univ. Calif. 28301). After drawings and photographs kindly furnished the present author by the University of California. Compare Matthew, 1930.

(Left) Palatal and side view of type skull, one-fifteenth natural size. Compare Matthew, 1930, text figs. 1 and 2.

(Right) Same type skull. Compare Matthew, 1930, Pl. xlii. One-fifteenth natural size.

Specific Characters.—(*Op. cit.*, Matthew, p. 339): "Last upper molar with four full crests and a considerable heel behind the fourth; in *P. matthewi* type there are three full crests with the fourth half-formed and a small rudiment of the fifth. Comparative measurements of this tooth are:

	[*Pliomastodon*]		[*Cordillerion*[1]]
	vexillarius	*matthewi*	*bensonensis*
Antero-posterior length	158	144	191
Width at anterior end	80	80	99
Width at fourth crest	71	48	. . .

Fig. 107. *Pliomastodon vexillarius*, type. Lower jaws, outside and occlusal views. One-fifth natural size. After Matthew, 1930, Pl. xliii.

Other measurements of teeth and skull—

	P. vexillarius	[*C.*] *bensonensis*
M^2, dimensions	107×71	125×88.5
Diameter of tusk (about a foot beyond alveolus)	165	130
Width of palate between M^1 alveoli =	155	120
Width of palate between M^3 alveoli =	88	76"

"The skull compares in bulk with the largest specimens of the American Mastodon. . . . From '*Tetralophodon*' *edensis* this species is separated by upcurved tusks lacking enamel band. . . . The skeletal parts preserved do not show any remarkable features."

Osborn, 1933: This interesting communication by Matthew, published posthumously, positively establishes *Pliomastodon* as an ancestral stage of *Mastodon* clearly distinguished by a far more primitive cranium, by a "narrow strip of thin enamel" within the alveolar base of the tusk, by the probable absence of inferior tusks, by the approximation of the condyles to the superior molars (M^3), by the extreme backward recession of the anterior nares and the shortening of the lower jaw, probably also with an unusual width of the occipital crest, suggesting an exceptionally large development of the proboscis.

As to bodily proportions, the type femur (*op. cit.*, Pl. xliv—Fig. 108) is much more massive than that of the Alaskan mammoth (*Mammonteus primigenius*) but indicating a massive body about 2800 mm., or 9 ft. 2¼ in., in height at the shoulder. The cranium apparently debars this species from direct ancestry of *Mastodon americanus*, for it embraces a number of peculiar characters. It is nevertheless most welcome as exhibiting a very distinctive, low-browed, flat-crested, abbreviated postcranial region, a very broad-crested occipital region, and broadly divergent premaxillary region with sharply upturned tusks. These features are clearly displayed in the outline and photographs (Fig. 106) after Matthew, 1930. An outline restoration of this animal, to the same scale as the Warren specimen of *M. americanus*, is shown in figure 110.

Fig. 108. Type femur of *Pliomastodon vexillarius* Matthew, front and side views. After photograph kindly forwarded to the present author by the University of California (cf. Matthew, 1930, Pl. xliv). About one-sixteenth natural size.

[1]Gidley's type of '*Anancus*' *bensonensis* is now referred to *Cordillerion bensonensis* (see p. 565 below).

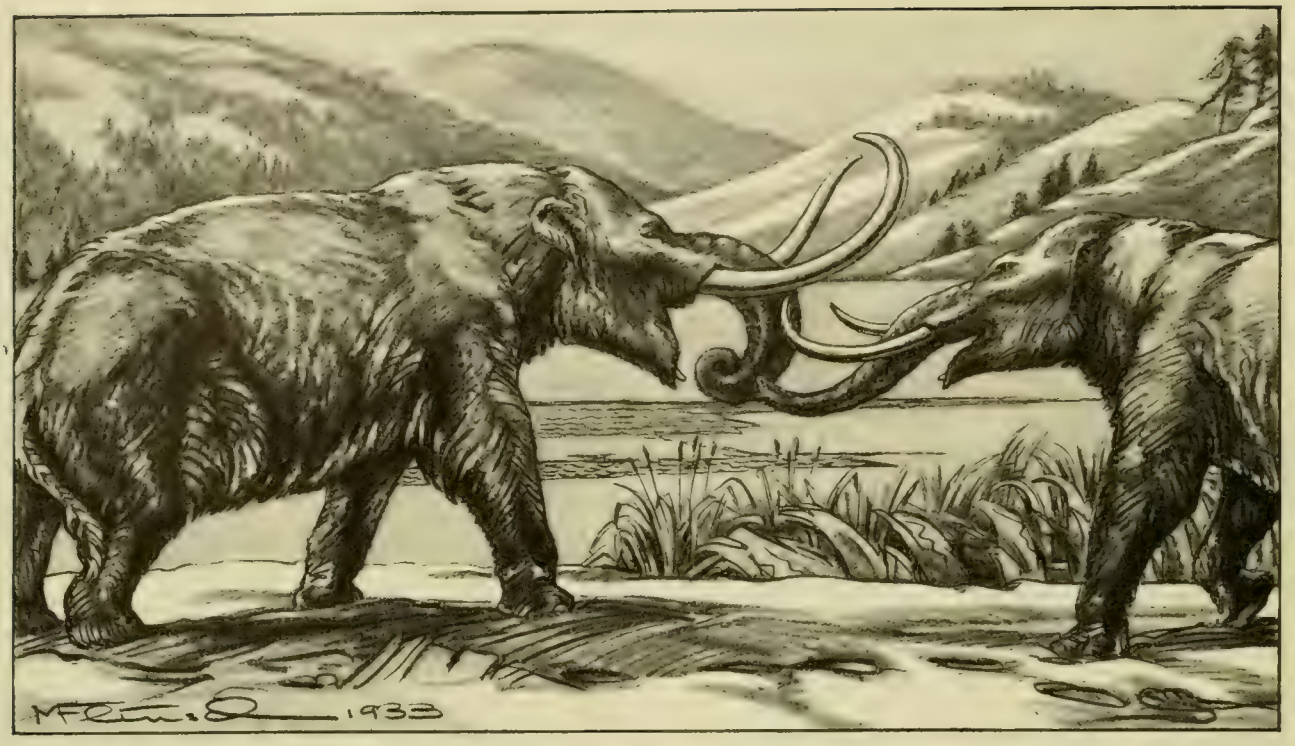


Fig. 109. Restoration (1933) of Male and Female Mastodon americanus by Margret Flinsch, under the direction of Henry Fairfield Osborn
One-fiftieth natural size

This restoration is based largely upon a record specimen (Fig. 114) of the American Mastodon in the Geological Museum of the Ohio State University, namely, with an estimated shoulder height in the flesh of 10 ft. 2 in.; it also embodies certain characters of the Warren Mastodon. The background is taken directly from a snow scene in the Hudson Highlands, near Newburgh, New York, where the Warren Mastodon was found.

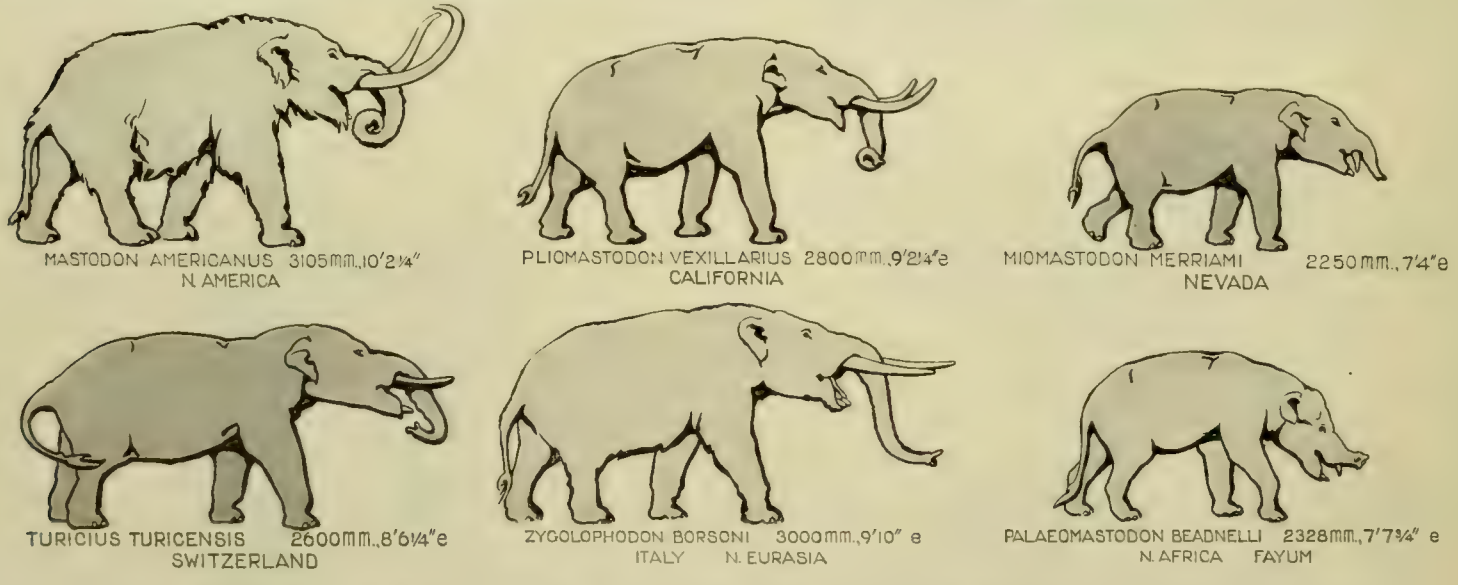


Fig. 110. Comparative Restorations of Palæomastodon, Pliomastodon, Miomastodon, Mastodon, Zygolophodon, and Turicius
One-hundredth natural size

Mastodon americanus, Mus. Ohio State Univ., adult bull of maximum size, restored after skeleton (Fig. 114).

Pliomastodon vexillarius, Mus. Univ. Calif. 28301, restored after type cranium and tusks, also femur, as described and measured by Matthew (pp. 161–163 above).

Miomastodon merriami, restored after type specimen from Nevada and referred specimen from Colorado (pp. 154–156 above).

Turicius turicensis, restored after type specimen of Schinz, in the Zurich Collection (Fig. 162).

Zygolophodon borsoni, restored after grinding teeth from Asti (Fig. 154) and superior and inferior tusks after Schlesinger (p. 211 below).

Palæomastodon beadnelli, as restored by Osborn (Fig. 97) from jaw, palate, and skeleton described and figured by Andrews, 1906 (Fig. 96).

(Osborn, 1934) *Palæomastodon* is now removed from its supposed ancestral relationship to *Mastodon*. As here restored, also in fig. 97, p. 149, the mouth parts and proboscis may be incorrectly drawn.

9. HISTORICAL REVIEW OF THE DISCOVERY OF THE GENUS MASTODON (1705–1935) AND OF THE SPECIES MASTODON AMERICANUS (1792–1869)

NOMENCLATURE.—The full history of this classic name is related in Chapter I, "Discovery of the Living and Extinct Proboscideans," in Chapter V, "History of the Classification of the Mastodontoidea, Families and Subfamilies (1705–1927)," and again in the introduction of the present chapter (Chapter VI), "History of the Subfamily Mastodontinæ, the True Mastodonts."

The first full summary of the vast generic and specific synonymy was that of Joseph Leidy in his great Memoir of 1869, p. 392. In our more recent and searching revision of the nomenclature of the Proboscidea we have found only one additional quaint and abortive name, *Mastotherium megalodon* Fischer de Waldheim, but doubtless further bibliographic research will in the future reveal still others.

Elephas americanus Kerr, 1792, Big-Bone Lick, Kentucky, near the Ohio River.
Ohio-Incognitum Blumenbach, 1797, same (?) locality.
Mammut ohioticum Blumenbach, 1799, same locality.
Elephas macrocephalus A. Camper, 1802, same (?) locality.
Le Grand Mastodonte Cuvier, 1806, same locality.
Mastodonte de l'Ohio, Cuvier, 1806, same locality.
Harpagmotherium canadense Fischer de Waldheim, 1808, Ohio (?) River (cf. Sherborn, 1924, p. 1022, "*Harpagonotherium canadense* . . . Anim. foss. Siberie.").
Mastotherium megalodon Fischer de Waldheim, 1814, Ohio.
Mastodon giganteum Cuvier, 1817, Big-Bone Lick, Kentucky, Ohio River.
Mastodon maximus Cuvier, 1824, Big-Bone Lick, Kentucky, Ohio River.
Tetracaulodon Mastodontoideum Godman, 1830, near Newburgh, Orange Co., New York.
Mastodon Cuvieri Hays, 1834.
Mastodon Jeffersoni Hays, 1834.
Tetracaulodon Collinsii Hays, 1834.
Mastodon Ohioticum 1832, Neues Jahrb. f. Min., p. 355, Gervais, 1848–1852.
Tetracaulodon Godmani Hays, 1834.
Missourium kochii Koch, 1840, Jefferson Co., Missouri.
Leviathan Missourii Koch, 1841, Missouri.
Tetracaulodon Tapyroides Koch, 1841, Missouri.
Tetracaulodon Osagii Koch, 1841, Missouri.
Tetracaulodon kochii, Koch, 1842, Missouri.
Tetracaulodon Haysii Grant, 1842.
Tetracaulodon Bucklandi Grant, 1842.
Missourium Theristocaulodon Koch, 1843.
Mastodon rugatum Koch, 1845.
Elephas Ohioticus de Blainville, 1839–1864.
Mastodon Ohioticus Falc. and Caut., 1845.
Elephas Rupertianus Richardson, 1854, Swan River, Lake Winnipeg basin, Canada.
Trilophodon ohioticus Falconer, 1868.
Mastodon americanus Leidy, 1868.

To our present knowledge the above names are *chiefly* synonyms of *Elephas* [*Mastodon*] *americanus* Kerr, but it is probable that some of these names were applied to specific or subspecific stages distinct from the type specimen Kerr had in mind, which came from the Big-Bone Lick of Kentucky. We may at present consider only the names of Kerr and of Blumenbach, and of the species defined subsequent to Leidy's Memoir of 1869, which are as follows:

Elephas americanus Kerr, 1792.
Ohio-Incognitum Blumenbach, 1797.
Mammut ohioticum Blumenbach, 1799.
Mastodon rugosidens Leidy, 1890.
Mammut progenium Hay, 1914.
Mastodon americanus plicatus Osborn, 1926.
Mastodon moodiei Barbour, 1931.
Mastodon raki Frick, 1933.
Mastodon americanus alaskensis Frick, 1933.
Mastodon grangeri Barbour, 1934.
Mastodon pavlowi sp. nov.
Mastodon acutidens sp. nov.

DISCOVERY AND DESCRIPTION OF THE OHIO MASTODON FROM GUETTARD, 1752, TO BUFFON, 1778, AND TO CUVIER, 1806–1836[1]

Cuvier (1821, p. 250) states that the first engraving of "une grande molaire de l'*Ohio*" is that of Guettard (Hist. Acad. Roy. Sci. avec Mémoires, Paris, 1752 [1756], p. 360, Pl. III, fig. 1 [Pls. 11, 12 of Memoirs]), but that the teeth of this animal did not attain real celebrity in Europe until between 1760 and 1770 through the Memoirs of Collinson (Phil. Trans., London, LVII, Pt. II, 1768, p. 468) and of Hunter (Phil. Trans., London LVIII, 1769, p. 34).

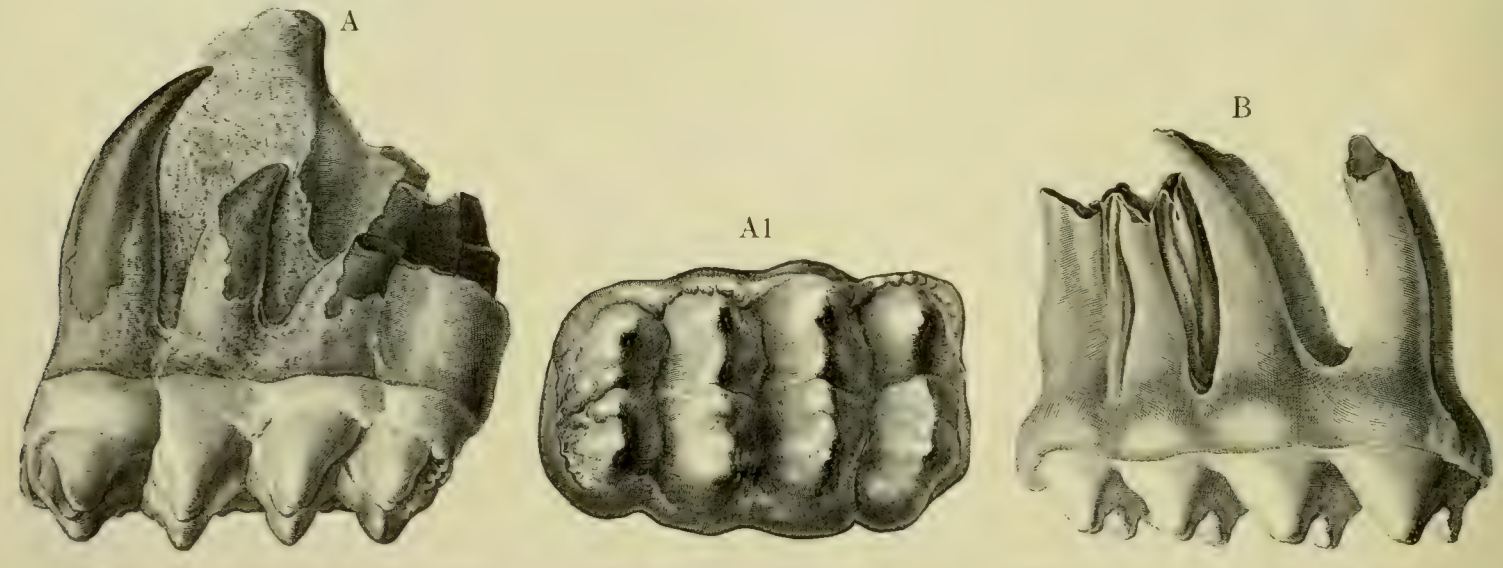
[1]Continued from Chapter V, pp. 118–129 of the present Memoir.

The name *Ohio*, moreover, is historic, since as early as 1765, as we learn from George Croghan's Journal and from Buffon (Buffon, 1778, p. 505):

> . . . dans les contrées voisines de la rivière d'*Ohio*, environ à 4 milles sud-est de cette rivière, éloignée de 640 milles du fort de Quesne, (que nous appelons maintenant *Pitsburgh*) . . . a vu, aux environs d'un grand marais salé, où les animaux sauvages s'assemblent en certains temps de l'année, de grands os & de grosses dents, & qu'ayant examiné cette place avec soin, il a découvert, sur un banc élevé du côté du marais, un nombre prodigieux d'os de très-grands animaux, & que par la longueur & la forme de ces os & de ces défenses, on doit conclure que ce sont des os d'éléphans.

Extracts from Croghan's Journal, communicated to Benjamin Franklin, appear in Buffon's Supplement (*op. cit.*, p. 507) accompanied by six admirable life-size steel engravings of mastodont grinding teeth, also citations from two little Memoirs by Collinson read before the Royal Society of London, in which Collinson remarks (Buffon, *op. cit.*, p. 509):

> Le marais salé où l'on a trouvé les os d'éléphans, n'est qu'à quatre milles de distance des bords de la rivière d'Ohio, . . Les ossemens d'éléphans se trouvent sous une espèce de levée ou plutôt sous la rive qui entoure & surmonte le marais à cinq ou six pieds de hauteur; on y voit un très-grand nombre d'os & de dents qui ont appartenu à quelques animaux d'une grosseur prodigieuse;



Buffon, 1778. Superior Grinding Teeth (A, A1) of Zygolophodon and (B) of Mastodon. Originals said to be in the Paris Museum (fide Pavlow, 1894)

Fig. 111. Grinding teeth of *Zygolophodon borsoni* referred (A, A1) and of *Mastodon americanus* referred (B), after Buffon, 1778, Pls. I, II, and IV, one-fourth natural size. [Inverted by H. F. O.]

A, A1, Buffon's figures of the molar of an animal which we now know to be related to *Zygolophodon borsoni*, found in Russia ("la petite Tartarie"), presented to Buffon in 1770 by M. le Comte de Vergennes. Observe three to four lobes, i.e., cones or conelets, in each transverse crest. (1778, Pls. I and II.)

B, Buffon's figure of the molar of an animal now known as *Mastodon americanus*, from Big-Bone Lick, Kentucky, near the Ohio River, sent to Buffon by M. Collinson. Observe two lobes, i.e., cones, in each transverse crest, the true *Mastodon* type. (1778, Pl. IV.)

Both of these beautifully engraved molar teeth appear to be third superior grinders, M^3, although they lack the rudimentary fifth crest or pentaloph characteristic of the third superior molars of *Mastodon americanus* (Fig. 133).

To Collinson's characterization, Buffon (*op. cit.*, p. 510) adds:

> Ce que dit ici M. Collinson, est très-vrai; ces grosses dents molaires diffèrent absolument des dents mâchelières de l'éléphant, & en les comparant à celles de l'hippopotame, auxquelles ces grosses dents ressemblent par leur forme quarrée, on verra qu'elles en diffèrent aussi par leur grosseur, étant deux, trois & quatre fois plus volumineuses que les plus grosses dents des anciens hippopotames trouvées de même en Sibérie & au Canada, quoique ces dents soient elles-mêmes trois ou quatre fois plus grosses que celles des hippopotames actuellement existans.

Buffon (*op. cit.*, p. 511) rightly compared the mastodont and hippopotamus teeth and rightly concluded:

> . . . comme on peut le voir en comparant les figures des *planches* I, III & IV, avec celles de la *planche* V. Il paroît donc certain que ces grosses dents n'ont jamais appartenu à l'éléphant ni à l'hippopotame; . . . je crois donc pouvoir prononcer avec fondement que cette très-grande espèce d'animal est perdue.

In brief, Buffon fully characterized this animal as a mastodont and designated it as an extinct species belonging to the epoch of the elephants but did not name it. This is sufficient evidence that the name *Ohio* was very prominent in the minds of the naturalists of the period, because the writings of Buffon dominated Europe at the time.

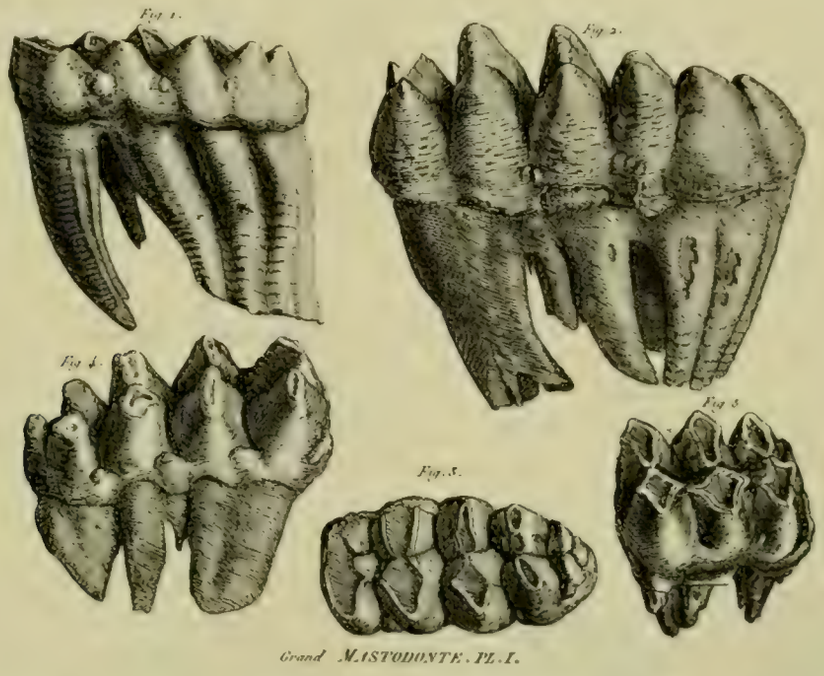


Fig. 112. Cuvier's types of *Le Grand Mastodonte*, or *Mastodonte de l'Ohio*, 1806. After Cuvier, 1806.2, Pl. 49 [1], one-half natural size.

(Cuvier, 1836, Atlas, Pl. 19): Fig. 2. Molaire à dix pointes encore intactes, donnée par le duc de Plaisance. Fig. 1. Dent à dix pointes en partie usée, du cabinet de Joubert, vue de profil. Fig. 3. Le même, vue par sa couronne. Fig. 4. Dent à dix pointes, rétrécie en arrière, communiquée par feu M. Tonnellier. Fig. 5. Molaire à six pointes à demi usée, d'après un dessin de M. Blumenbach.

Cuvier, 1806–1836. —Cuvier practically defined the genus '*Mastodonte*' in his admirably engraved *Planches* and in the descriptive legends of these plates. In the descriptions he acknowledges his indebtedness for one of the drawings to Blumenbach and for one or two of the cotype specimens to Fabri, to Daubenton, to Joubert, and to Tonnellier. Referring to Buffon's idea that the mastodont grinders were those of the "hippopotames gigantesques," he pointed out that they were distinguished by the worn '*losanges*' which differed greatly from the worn "trèfles de l'hippopotame."

(Cuvier, 1806.2, p. 293): "Notre pl. I représente quatre de ces dents de *mastodonte* à moitié grandeur. Fig. 5 en est une à six pointes à demi-usées: elle est copiée d'après un dessin qu'a bien voulu m'envoyer M. *Blumenbach*. Nous en avons au Muséum trois pareilles, anciennement rapportées par *Fabri*. Ce sont elles que *Daubenton* (*Hist. nat.* XII, n.° 1106, 1107, 1108), et *Buffon* (*Epoques de la nature*, pl. V) ont prises pour des dents d'*hippopotames gigantesques*. Elles sont aisées à distinguer par ces *losanges*, dont notre figure donne une idée fort juste, et qui diffèrent beaucoup des trèfles de l'*hippopotame*. D'ailleurs l'*hippopotame* n'a jamais que quatre trèfles et non pas six." Compare Daubenton, 1764, p. 77, No. MCXI "*Dent pétrifiée qui a quelque rapport à celles de l'hippopotame.*"

Original Description of Elephas americanus by Kerr, 1792. No Figure

Succeeding Buffon's description (1778) of the American Mastodon but anticipating Cuvier's description of *Le Grand Mastodonte*, 1806, the Scottish naturalist Robert Kerr proposed the specific name *Elephas americanus* for tusks and grinders found in the 'Big-bone-swamp' on the banks of the Ohio. He pointed out that these teeth were specifically different from those of the elephant and furnished with a double row of high conic processes resembling those of carnivorous animals. This contribution appears in a translation of portions of at that time a recent edition of the "Systema Naturæ" of Linnæus, with improvements by Professor Gmelin, entitled, "The Animal Kingdom or Zoological System, of the Celebrated Sir Charles Linnæus," published in 1792, as follows:

> (Kerr, 1792, p. 116): 2. American Elephant.—*Elephas americanus.* In America, on the banks of the Ohio, are found, several feet below the surface, in a marshy place called Big-bone-swamp, great numbers of tusks and grinders, supposed by many to belong to the Elephant: But the grinders are totally different, being covered uniformly with enamel, and furnished with a double row of high conic processes, like those of carnivorous animals; whereas those of the Elephant are composed of alternate perpendicular layers of bone and enamel, and are ribbed transversely on their upper surfaces, like those of graminivorous quadrupeds: Hence the species must be entirely different; and Mr. Pennant has chosen to suppose that they have belonged to an unknown species of this genus, which he names the American Elephant. Hist. of Quad. n. 71.

Original Description of the Ohio-Incognitum by Blumenbach, 1797

The next name applied to the animal was that of Johann Friedrich Blumenbach, pioneer vertebrate palæontologist of Germany, who received from the British Museum his type specimen (Fig. 113), a third superior molar tooth of the left side. Blumenbach subsequently corresponded and exchanged drawings and notes with Cuvier, as mentioned above.

Fig. 113. *A*. Type left third superior molar of *Ohio-Incognitum* Blumenbach, 1797. Reproduced in facsimile after Blumenbach, 1797.2, No. 19. Same figure in edition of 1810 designated on the Plate as *Ohio-Incognitum*. Technically a *type* figure. [=*Mastodon americanus*.]

> (Blumenbach, 1797.2, No. 19): Bey jenem fossilen Ungeheuer der präadamitischen Vorwelt sind die zackichten Kronen ganz mit einer starken Lage vom so genannten Schmelz (*substantia dentium vitrea*) überzogen: da hingegen die Backenzähne beider Gattungen des Elephantengeschlechts aus vertical liegenden abwechselnden Schichten von Schmelz und Knochensubstanz bestehen. . . . Der vom *fossilen* Incognitum hingegen nach einem ungeheuern am Ohio ausgegrabenen Exemplar, das mir aus dem Britischen Museum für meine Sammlung überlassen worden.

Osborn, 1922: *Ohio-Incognitum* is the name and figure cited by de Blainville (1839–1864, p. 245). We observe that Blumenbach's figure of *Ohio-Incognitum* (1797. 2, No. 19) is of a third superior molar of the left side, with very pronounced internal cingulum. There are four and a third lophs; there are two mamillate lobes on each crest in the figure. The above description by Blumenbach (*op. cit.*, No. 19) shows that he secured this specimen from the British Museum as part of its Ohio River collection.

The Name Mastodon americanus as established by Leidy, 1868, 1869

Specific Name.—Leidy concludes his full revision of the American species of *Mastodon*, in his great Memoir of 1869, with the sentence (Leidy, 1869, p. 240): "One of the species, the well known *Mastodon ohioticus*, or *M. americanus* as I shall hereafter call it, appears to have roamed throughout the continent during the quaternary period." The dates of these species are *Elephas americanus* Kerr, 1792, and *Mammut ohioticum* Blumenbach, 1799; to the best of our knowledge Blumenbach (1799) was the first to use the name *Mammut*

ohioticum; in the Neues Jahrbuch, 1832, p. 355 (see Eichwald), the term *Mastodon ohioticum* is used, and Leidy states in his Memoir of 1869, p. 394, that Gervais used this term *'ohioticum'* in his "Zoologie et Paléontologie Francaises," 1848–1852, I, p. 187. The name *Mastodon americanus* was first used by Leidy in 1868, in Volume XX of the Proceedings of the Academy of Natural Sciences of Philadelphia, p. 175, to embrace the *Mastodon ohioticus* or *M. giganteus* of authors.

Generic Name.—The generic name *Mastodon* was universally accepted by palæontologists in all parts of the world until 1902, when the vernacular generic term *Mammut* of Blumenbach (1799) was revived by Hay, although subsequent to the vernacular term *Ohio-Incognitum* of Blumenbach. Unfortunately this vernacular synonym *'Mammut'* entered the American literature between 1902 and 1925 and occurs in the writings of Palmer, Lull, Barbour, Stock, Daggett, and others. In Chapter I of the present Memoir, "Discovery of the Living and Extinct Proboscideans," and in the foregoing pages of the present chapter (Chap. VI), "History of the Subfamily Mastodontinæ, the True Mastodonts," ample reasons are given for the banishment from all future proboscidean literature of this barbaric term *'Mammut.'*

Subsequent to Leidy's Memoir of 1869 nine species have been proposed, namely, *Mastodon rugosidens* Leidy, 1890, *'Mammut' progenium* Hay, 1914, *Mastodon americanus plicatus* Osborn, 1926, *Mastodon moodiei* Barbour, 1931, *Mastodon raki* Frick, 1933, and *Mastodon americanus alaskensis* Frick, 1933. The validity of Leidy's *M. rugosidens*, 1890, and of Osborn's *M. americanus plicatus*, 1926, is a question of further research. *Mastodon pavlowi*, also *Mastodon acutidens*, a very progressive stage, are proposed by Osborn in the present Memoir (see Appendix). In 1934 Barbour described the straight-tusked species *Mastodon grangeri* from Nebraska (see Appendix at close of Volume I for description and figure).

The Largest Fully Adult Male Skeleton of Record; Estimated Shoulder Height 10 Feet 2 Inches in the Flesh. (See Fig. 109)

Fig. 114. Mounted skeleton of *Mastodon americanus* from Catawba, Ohio, in the Ohio State University, Geological Museum, after photograph kindly sent the present author by Prof. J. Ernest Carman, Chairman of the Department of Geology. Reproduced about one twenty-fourth natural size.

10. CHARACTERS OF MASTODON AND ITS INCLUDED SPECIES AND VARIETIES

SUPERFAMILY: MASTODONTOIDEA Osborn, 1921

FAMILY: MASTODONTIDÆ Girard, 1852

SUBFAMILY: MASTODONTINÆ Brandt, 1869—Osborn, 1910

GENUS: **MASTODON** Cuvier, 1806–1817

Original reference: *Mastodonte*, "Sur Le Grand Mastodonte," Cuvier, 1806.2, pp. 270, 272, 293; *Mastodon*, "Le Règne Animal," Cuvier, 1817, pp. 232, 233.

Genotypic species: *Mastodon giganteum.*

Synonyms: *Mastotherium* Fischer de Waldheim, 1814, pp. 337–341.

GENERIC CHARACTERS.—Incisive tusks without enamel; superior tusks large and rounded with slightly indicated annular ring growths. Inferior tusks straight, cylindrical, variable in old age. Marked sexual disparity in female tusks. Permanent premolars suppressed,[1] except the vestigial P^4-P_4.

Dental formula: $I\frac{0-2-0}{0-2-0}$ $Dp\frac{2-3-4}{2-3-4}$ $P\frac{4}{4}$ (vestigial) $M\frac{1-2-3}{1-2-3}$

Intermediate molars, Dp 4-M 2, trilophodont, i.e., with three ridge-crests. Ridge-crests progressively elevated, lophodont to subhypsodont. Cingulum of grinding teeth slightly stronger on the inner side than on the outer side (in *Serridentinus* much stronger on the inner side). Grinders bilobate with strong median sulcus between the inner and outer lobes. Very rudimentary trefoil spurs on the superior inner lobes and on the inferior outer lobes (compare Fig. 133). Summits of lobes simple or crowned with small conelets. Progressive elevation, subhypsodonty, of the lobes (cf. Figs. 112, 135). Progressive plication of the surface enamel of the grinding teeth (Fig. 120). Progressive development of the third crest (tritoloph and -lophid) in intermediate molars; progressive development of the fifth crest rudiment (pentalophid) in third inferior molars. Progressive reduction of the rostrum of the lower jaw (see *M. progenius* and *M. americanus*).

The above list of generic characters enables us to distinguish clearly the Pleistocene species of the true American Mastodon from their Pliocene and Miocene ancestors *Pliomastodon* and *Miomastodon*. Whereas M^3-M_3 show a rudiment of the fifth crest in *Mastodon americanus* (Figs. 116, 117), no such rudiment is observed in *Miomastodon merriami* of the Middle Miocene. These progressive characters of the grinding teeth in the Mastodontinæ phylum are well displayed in figure 98, also in Pl. 1, pp. 134–135.

Mastodon americanus Kerr, 1792

Figures 76, 112, 114, 116, 117, 124–126, 128–130, 132–134, 136, Pl. 1, p. 134

Big-Bone Lick, Boone County, Kentucky, late Pleistocene, IV Glacial = Wisconsin time.

The history of this classic species is fully recited above in the present chapter of this Memoir. Cuvier's types of the genus '*Mastodonte*' (=*Mastodon*) are reproduced above in figure 112. Unfortunately Kerr's type of the species *Elephas* [=*Mastodon*] *americanus* was not figured.

TYPE DESCRIPTION.—Kerr's type description is cited in full above (p. 168) and need not be repeated here. The *type locality*, however, deserves very careful description. *Mastodon americanus* from Big-Bone Lick, Kentucky, as figured by Cuvier (see Fig. 112 of the present Memoir) probably belongs to IV Glacial = Wisconsin time; the molars are much more primitive than those of *M. acutidens* sp. nov.

TYPE LOCALITY OF THE SPECIES MASTODON AMERICANUS.—Big-Bone Lick, Boone County, Kentucky, is undoubtedly the type locality both of the genus '*Mastodonte*' (=*Mastodon*) Cuvier and of the species *Elephas* [=*Mastodon*] *americanus* Kerr. This famous salt swamp or salt lick was probably visited by the ungulates for a long period of geologic time, as shown by the latest analysis of its contained fauna (see Hay, 1923.1). In the list of species by Hay (p. 403) cited below references are made in his Memoir on "The Pleistocene of North America and Its Vertebrated Animals" to pages whereon further information is given regarding the respective species.

Hay believes (*op. cit.*, 1923, p. 403) that the Big-Bone Lick fauna followed Glaciation III (=Illinoian) and belongs chiefly in *3rd Interglacial* time (=Sangamon interval); he accordingly assumes that the animals were buried during the Sangamon stage in the interval between the Illinoian (III) and the Wisconsin (IV) glaciations; the presence of *Mammonteus primigenius* in the Big-Bone Lick deposits rests (*op. cit.*, p. 146) on the determination of a single superior molar tooth with 23–24 plates, which Osborn considers may be referable to *Parelephas jeffersonii*.

[1]See page 138 for observations of Hays and of Warren, namely, that P 4 forms in the jaw but does not erupt; it is therefore vestigial.

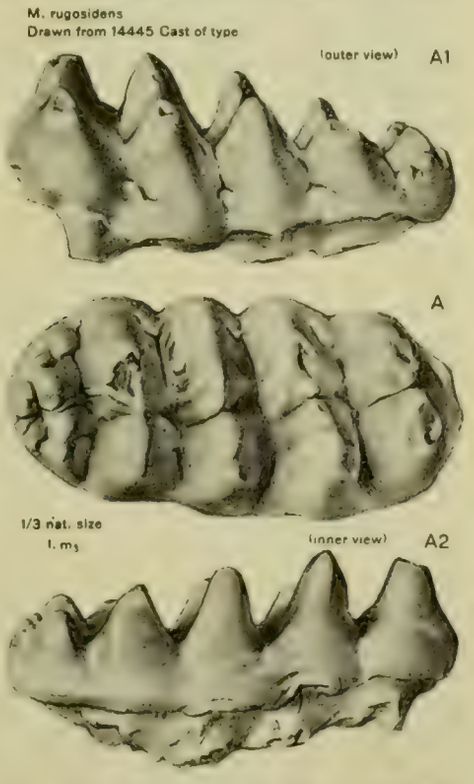
Megalonyx jeffersonii (p. 44).
Mylodon harlani (p. 44).
Equus complicatus (p. 202).
?Tapirus haysii (p. 209).
Odocoileus virginianus (p. 234).
Cervus canadensis (p. 243).
Cervalces scotti.
Alces americanus.
Rangifer caribou (p. 247).
Boötherium bombifrons (p. 255).
Symbos cavifrons (p. 255).
Bison antiquus (p. 265).
Bison bison (p. 270).
Mammut americanum (p. 128). [=*Mastodon americanus* type
Elephas primigenius (p. 146). =*Mammonteus primigenius* ref.(?)
Elephas columbi (p. 160). =*Parelephas jeffersonii* ref.(?)]
Ursus americanus.

Mastodon americanus rugosidens Leidy, 1890

Figure 115

Santee Beds of Beaufort County, South Carolina; Pleistocene.

Mastodon rugosidens Leidy, 1890. "Mastodon and Capybara of South Carolina." Proc. Acad. Nat. Sci. Phila., Vol. XLII, 1890, p. 184. TYPE.— . . . "complete crown of a last upper [lower] molar, strikingly different from that tooth in the common American Mastodon . . . looking as if carved out of ebony, as is the case with many of the fossils from the same and similar localities." TYPE LOCALITY.—"It was found in the Santee Beds of Beaufort Co., S. C." and "was presented to the Academy by Mr. James R. McKee." TYPE FIGURE.—Drawn from cast of type (Amer. Mus. 14445—Fig. 115 of the present Memoir).



TYPE OF MASTODON AMERICANUS RUGOSIDENS

Fig. 115. Last inferior molar of the left side, l.M_3. Type of *Mastodon rugosidens* Leidy (Philadelphia Academy). Drawn from cast of type (Amer. Mus. 14445), one-third natural size.

A, Crown view; A1, external view; A2, internal view.

TYPE DESCRIPTION.—(Leidy, 1890.2, p. 184): "It is worn only on the summits of the anterior pair of lobes, which display the usual exposed dentinal areas. Notwithstanding the many species of Mastodon which have been recorded in North and South America, the present tooth seems to indicate a different one. It more nearly resembles the corresponding tooth of the *M. floridanus*, recently described, or that of the *M. angustidens* of Europe, than of the *M. americanus*. In comparison with the molars of these and other known species the tooth is remarkable for the greater proportionate length of the constituent lobes of the crown and their conspicuously wrinkled condition. The wrinkling is longitudinal and regular and apparently not the result of an abnormal state. Similar wrinkling is observed in some specimens of the same teeth in *M. americanus*, but mainly confined to the intermediate vallies of the crown, while it is well produced laterally in the present fossil. From the comparatively more prolonged condition of the lobes, the summits of the inner ones appear more tapering or narrowly pointed than in *M. floridanus;* while with the fore and aft extensions of the same lobes the summits form acute and not obtuse angles as in the latter. Regarding the specimen as indicating a previously unknown species, this may be distinguished as the MASTODON RUGOSIDENS.

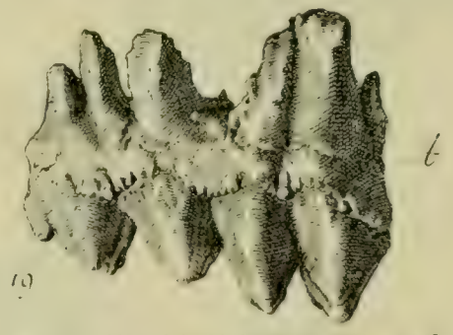


Fig. 116. Type left third superior molar, l.M^3, of *Ohio-Incognitum* Blumenbach, 1797. Reproduced in facsimile after Blumenbach, 1797.2, No. 19. Same figure in edition of 1810 designated on the Plate as *Ohio-Incognitum*. [=*Mastodon americanus*.]

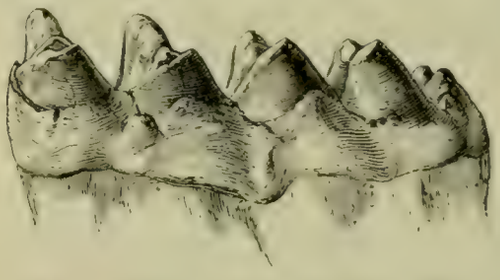


Fig. 117. Inferior molar of the left side, l.M_3, of *Mastodon americanus*. One-fourth natural size. The record of the specimen, from which this beautiful drawing was made by Mr. R. Weber, has been lost.

Comparative measurements of the tooth are as follows:

	M. rugosidens	*M. floridanus*
Length of crown fore and aft	190 mm.	190 mm.
Breadth of base at fore part	92 mm.	96 mm.
Length of second inner lobe	90 mm.	80 mm.
Length of second outer lobe	80 mm.	62 mm."

Osborn, 1925: The type cast (Amer. Mus. 14445), from the original type in the Academy of Natural Sciences, Philadelphia, agrees exactly in measurement with Leidy's description (Leidy, 1890.2, p. 184) cited above; thus there is no mistaking the type. Leidy erred, however, in describing it as "a last upper molar"; it is certainly a last lower molar of the left side, l.M_3, as shown by careful comparison of the type with third inferior grinding teeth and with the specimen beautifully displayed in figure 117.

It is doubtful also whether the wrinkling of the enamel, to which the specific name *rugosidens* applies, is actually of specific value.

TYPE OF MASTODON PROGENIUS

Fig. 118. Type jaw of '*Mammut*' *progenium* Hay, 1914, Pl. XLIV, figs. 1 and 2. From Cox gravel pit, Missouri Valley, Harrison County, Iowa. Described by the present author as *Mastodon progenius*.

Mastodon progenius Hay, 1914

Figure 118

Cox gravel pit, Missouri Valley, Harrison County, Iowa, early Pleistocene, probably *1st Interglacial*, Aftonian age, *fide* Hay.

This species is of great interest as representing an *early* Pleistocene stage in the development of the true *Mastodon*. Of *1st Interglacial* or Aftonian age it is much more primitive than the type of *Mastodon americanus* of *3rd(?) Interglacial* or Sangamon age.

Mammut progenium Hay, 1914. "The Pleistocene Mammals of Iowa." Iowa Geol. Surv., 1914, XXIII (Ann. Rept., 1912), pp. 368–373. TYPE.—Lower jaw of a very old animal, with last molar in each side of jaw, worn down to the roots. Univ. of Iowa No. 292. HORIZON AND LOCALITY.—Apparently found in 1910, in the Cox gravel pit, at Missouri Valley, Harrison County, Iowa; of Aftonian age. TYPE FIGURE.—Hay, *op. cit.*, 1914, Pl. XLIV, figs. 1 and 2. "It was described and figured by Calvin in 1911 (Bull. Geol. Soc. Amer., Vol. XXII, p. 213, Pls. XX and XXI) under the name *Mastodon americanus*. Figures are here presented which are made from the same photographs as those used by Calvin . . . but reduced in size" (p. 368).

TYPE DESCRIPTION.—(Hay, 1914, p. 369) . . . "symphysis of lower jaw longer than in *M. americanum;* chin less constricted at the symphysis, as viewed from above, and not truncated in front. . . . The following are the dimensions of this jaw as furnished by the measurements of Calvin and the writer [Hay].

Length from front of symphysis to hinder border just above the angle	830 mm.
Length from front of symphysis to rear of condyles, in straight line	920 mm.
Height of coronoid process above lower border of the jaw	425 mm.
Height of condyles above lower border of jaw	410 mm.
Length of the symphysis	212 mm.
Height of the jaw at the front of m_3	192 mm.
Thickness of the jaw at the front of m_3	120 mm.
Width of the ascending ramus, from rear of the condyle	290 mm."

The symphysis of *M. progenium* is relatively much longer than in *M. americanum;* its length equals eighty per cent. of the width of the ramus. The rami cease to diverge opposite M_3 and there is even some constriction. "Occasionally in the lower jaw of *M. americanum* there is a single tusk, rarely two of them . . . in the lower jaw of the extremely old animal under description here, both tusks were present. Their presence is indicated by the widely open sockets. The vertical diameter of the socket measured, the right, is 73 mm.; the transverse diameter, 50 mm. These measurements show that the tusks were far larger than those now and then found in *M. americanum*. The depth of the socket is 160 mm. The measurements show likewise that the tusks were considerably compressed, the horizontal diameter being about two-thirds of the vertical. What the form and the length of these tusks were, beyond the sockets, we can only surmise. . . . In the type jaw the lingual gutter is somewhat peculiar in being overhung on each side by the upper borders of the jaw. These approach until they are only 28 mm. apart. On the outer face of this part of the jaw the surface is concave as it rises to the dental border. In this specimen the penultimate molar, m_2, had been pushed out on the right side of the jaw before the death of the animal; that of the left side seems to have been lost after death, for there remains a part of one root. As stated, the crown of m_3 is worn down to its base. The grinding surface of the left molar forms a concavity which is surrounded by a ring of enamel; but on the right side a part even of this is missing. This attrition of the tooth had so weakened it that, before the death of the animal, the teeth had each split into two parts. The inner wall of each had broken at the middle of the second crest and the cleft had run backward and outward to near the hinder end of the tooth. That this had occurred before death is evident, as Calvin remarked, from the fact that the edges of the fracture had been rounded off. The right tooth has another cleft, which crosses its front; but Calvin concluded that this was a post-mortem break. It is not improbable, however, that it happened under the strain of chewing just before death of the animal. It is evident that the hinder molar had four transverse crests and a heel which was essentially a crest."

Referred Specimen.—Left ramus and symphysis of lower jaw, figured by Calvin under the name *Mammut americanum* (Calvin, 1909, p. 352, Pl. xxv, fig. 2), referred provisionally by Hay to *Mammut progenium* because of the resemblances of the jaw to the type. The referred specimen is figured by Hay on Pl. xlviii, fig. 1; Pl. lii, fig. 2.

Type of Mastodon oregonensis

Fig. 119. Type figures of *Mammut* [=*Mastodon*] *oregonense* Hay, 1926, figs. 1, 2, about one-half natural size, from Rye Valley, on Dixie Creek, Baker County, Oregon (Nat. Mus. 4911). A second superior molar of the left side, l.M². The crenulate crowns resemble those of *Mastodon americanus plicatus* Osborn (Fig. 120), a synonym.

Mastodon oregonensis Hay, 1926

Figure 119

Rye Valley, Dixie Creek, Baker County, Oregon. Probably Pleistocene. Compare *Mastodon americanus plicatus* Osborn, 1926.

Mammut oregonense Hay, 1926. "Two New Pleistocene Mastodons." Journ. Washington Acad. Sci., Vol. XVI, No. 2, Jan. 19, 1926, pp. 39 to 41. Type.—A second superior molar of the left side, l.M², Nat. Mus. 4911. Horizon and Locality.—This molar was "found by the Cartwright Brothers, placer miners, at Rye Valley, on Dixie Creek, in township 13 south, range 43 east [Oregon]." Probably Pleistocene. Type Figure.—*Op. cit.*, p. 36, figs. 1 and 2.

Type Description.—(Hay, *op. cit.*, 1926, pp. 39 and 40): "In the U. S. National Museum is a mastodon tooth (Cat. no. 4911) which was sent there in November, 1900, by Dr. Waldemar Lindgren, from Baker City, Baker County, Oregon. It had been found by the Cartwright Brothers, placer miners, at Rye Valley, on Dixie Creek, in township 13 south, range 43 east. Dr. Lindgren reported that the tooth had been found in a fluviatile clay bed which had formed a part of a bench of auriferous gravels, overlying the Payette beds. He regarded the fluviatile clay as of Pliocene age. It appears more probable that the bed belonged to the Pleistocene, for in it was discovered a tooth of *Elephas columbi*. . . . The type tooth here described and figured is the upper left second molar. It has been regarded as belonging to *M. americanum*, but it is so different that the writer ventures to give it a distinct name. The tooth had apparently not yet begun to suffer wear; or, if at all, only slightly on the first cross-crest. The length is 111 mm.; the width of the front end, 74 mm.; of the rear end, 80 mm. The crown presents 3 cross-crests and, in the rear, a talon. The crests are high, and the valleys narrow. The ends of the cross-crests slope steeply and nearly equally. The summits of the two principal cones of each crest are well separated, as follows: First crest, 38 mm., second, 40 mm., third, 40 mm. . . . All around the tooth is a heavy cingulum composed, at the pretrite ends of the valleys, of 5 or 6 tooth-like conules. On the posttrite side the conules are smaller and more numerous."

Mastodon americanus plicatus Osborn, 1926

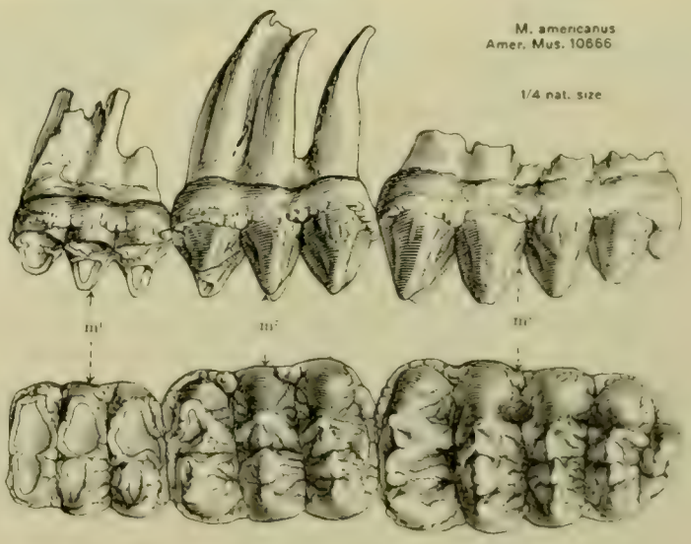
Figure 120

Geologic age uncertain, possibly of Postglacial (IV) or post-Wisconsin age. From Walnut, Bureau County, Illinois.

The type of this species is a superior true molar series of the right side, r.M¹⁻³, from Walnut, Illinois, in the American Museum collection (Amer. Mus. 10666).

Mastodon americanus plicatus Osborn, 1926. "Additional New Genera and Species of the Mastodontoid Proboscidea." Amer. Mus. Novitates, No. 238, November 30, 1926, p. 1. Type.—Superior true molar series of the right side, r.M¹⁻³. Amer. Mus. 10666. Horizon and Locality.—Walnut, Illinois. Geologic age uncertain, possibly of Postglacial (IV) or post-Wisconsin age. Type Figure.—*Op. cit.*, 1926.706, p. 2, fig. 1.

Specific Characters.—(*Op. cit.*, 1926.706, p. 1): "This progressive subspecies is distinguished by numerous minor foldings, valleys, and plications which break up all the surfaces of the lophs or lobes and which to a certain degree indent even the summits of the ridge-crests."



Type of Mastodon americanus plicatus

Fig. 120. Type superior true molar series of *Mastodon americanus plicatus* Osborn (Amer. Mus. 10666), from Walnut, Bureau County, Illinois. One-fourth natural size. After Osborn, 1926.706, p. 2, fig. 1. Compare *Mastodon oregonensis* Hay (Fig. 119).

"As in the case of the type of *Mastodon rugosidens* Leidy, it is somewhat doubtful whether these foldings and plications represent constant specific characters. Consequently the teeth are given merely subspecific rank, pending a fuller study of the dental characters in the *Mastodon americanus* molar teeth in America."

Mastodon moodiei Barbour, 1931

Figure 121

West Blue River, about nine miles southwest of Milford, Seward County, Nebraska. Pleistocene, II Glacial, Kansan. See Pleistocene Correlation Chart in Appendix of the present Volume I.

The type cranium of this species, discovered during the winter of 1931, was unearthed, together with the atlas, axis, two thoracic vertebræ, and ribs, between March and June of the same year. It was named by Doctor Barbour *Mastodon moodiei*, after Dr. Roy L. Moodie of the University of Southern California.

Mastodon moodiei Barbour, 1931. "The Milford Mastodon, Mastodon moodiei, Sp. Nov. A Preliminary Report." Neb. State Mus., Bull. 24, Vol. I, December, 1931, pp. 203–210 (Barbour, 1931.3). TYPE.—Skull, together with atlas, axis, two thoracic vertebræ, ribs, and mandible with teeth. Neb. Mus. 21–3–31. protruded 6 or 8 feet or more. . . . By the position of the fragments the tusks were judged to have been 6 to 8 feet in length. .

MEASUREMENTS

Transverse diameter of condyle, 5 inches (127 mm.)
Depth in front of the molar, 7⅛ inches (180 mm.)
Depth just back of the molar, 6¾ inches (172 mm.)
Greatest thickness, 7 inches (182 mm.)
Length of molar, 6⅞ inches (175 mm.)
Width of molar, 3¾ inches (96 mm.)
Length of mandibular tusks, 9¼ inches (235 mm.)
Diameter of tusk, 2 inches (51 mm.)

The beds which yielded the relics of Mastodon moodiei are plainly Pleistocene in age, probably Aftonian."

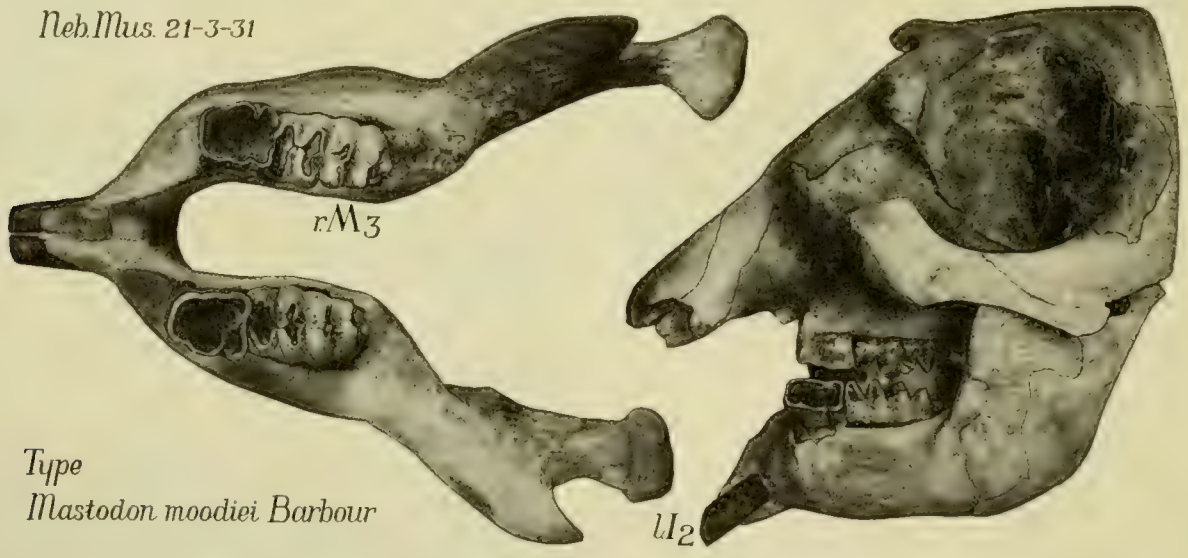


Fig. 121. TYPE OF MASTODON MOODIEI BARBOUR, THE MILFORD MASTODON OF NEBRASKA, MORRILL PALÆONTOLOGICAL COLLECTIONS (NEB. MUS. 21–3–31)

(Left) Adult mandible with M_2, M_3, crown view. About one-sixth natural size.

Rostrum relatively long, laterally compressed; short, blunt incisive tusks worn off squarely at tips. Compare figure 87.

(Right) Type skull and mandible. About one-twelfth natural size.

The mandible exhibits a downcurved rostrum with two blunt incisive tusks sharply worn off at the extremities.

HORIZON AND LOCALITY.—Dam No. 7, across the West Blue River, about nine miles southwest of Milford, Seward County, Nebraska. Pleistocene, II Glacial, Kansan. TYPE FIGURE.—Barbour, *op. cit.*, figs. 130, 131, 132*b*. See also new figures of type in the present Memoir (Fig. 121).

SPECIFIC CHARACTERS.—(Barbour, 1931.3, pp. 206, 207, 210): "Both mandibular tusks were secured uninjured. They are dense and strong and slightly curved. They measure 9¼ inches (235 mm.) in length, and the pulp cavity is shallow, measuring but ½ inch (13 mm.) in depth. Each mandibular tusk ends squarely, for an indefinite amount has been worn off in some manner. To have thus ground them off it seems as though the creature must have designedly rubbed his tusks on rocks. Yet the interference offered by the great protruding upper tusks must have rendered such a procedure impossible. The incisive sheaths show that the upper tusks had a diameter of 4 inches, and they must have

MANDIBULAR TUSKS AS RECENTLY OBSERVED BY BARBOUR 1931).—The mandibular tusks of *Mastodon americanus* (cf. Barbour, 1931.1, pp. 163, 164) were waning inheritances from the past, which plainly required ages for reduction and suppression, and complete elimination was never a reality. In the majority of jaws, the inferior tusks are wholly wanting; in others the tusks have not been erupted, but lie embedded in the bone; sometimes one or two small tusks are erupted; in still other cases large ones appear.

The Warren mastodon in The American Museum of Natural History (Fig. 124) had a solitary dwarfed tusk in the mandible, and hence was named *Tetracaulodon*, and the term might still be used conveniently to designate mastodons possessed of mandibular tusks. The tetracaulodont type of mastodon is not particularly rare, for there are two good examples in Amherst. Hay reported several, and Warren, studying mastodon jaws, found nine of this

type. There is one example in the Nebraska State Museum. In the museums of the country many others can doubtless be found The presence of mandibular tusks in mastodon jaws is partly a sexual character, those with tusks being males, those without, females.

In the Amherst Museum is a jaw from Nine Mile Bottom, South Carolina, displaying inferior tusks 14 in. in length (Barbour, *op. cit.*, fig. 103), whereas the Warren Mastodon in the American Museum shows only one small vestigial mandibular tusk (*op. cit.*, fig. 104). In the 'Monroe mastodon' of Orange County, New York, in the State Museum, Albany, there are two dwarfed and irregular mandibular tusks. In the 'Seward County Mastodon' of Nebraska (Neb. Mus. 11–7–25), the two mandibular tusks were probably 12–18 in. in length (*op. cit.*, fig. 106).

From all these geologic, phylogenetic, and sexual variations of the mandibular tusks, we draw the induction that at the beginning of Pleistocene time not only was the rostrum of the mandible much longer than at the close of Pleistocene time, as illustrated in *Mastodon progenium* Hay, but the pair of lower mandibular tusks were much more fully developed, as illustrated in the case of the 'Seward County Mastodon' (Barbour, *op. cit.*, fig. 106), which was found 75 feet below the surface in interglacial gravels.

Mastodon grangeri Barbour, 1934

From near Pender, Thurston County, Nebraska.

For full description, with figures, of *Mastodon grangeri*, see Appendix of the present Volume I.

Mastodon raki Frick, 1933

Figure 122

From Hot Springs, New Mexico. Pleistocene.

Mastodon raki Frick, 1933. "New Remains of Trilophodont-Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, pp. 506, 510, 630. TYPE.—(*Op. cit.*, p. 630): "Right ramus and symphysis and part of left ramus with m_2-m_3. F:A.M. 23335." From Hot Springs, New Mexico. Found in 1927. Pleistocene. TYPE FIGURE.—*Op. cit.*, figs. 25A and 29A.

TYPE DESCRIPTION.—(Frick, 1933, p. 630): "A right and broken left ramus with m_1 alveolus, m_2-m_3 and partial symphysis, from the Pleistocene of New Mexico, is of the general proportions typical of *Mastodon americanus*-like forms. On the character of the heel and the m_3 crown, which is narrower and taller than usual, the specimen is referred to a new species."

Osborn, 1933: Osborn observes (Fig. 122) that the type third right inferior molar exhibits the following: (1) Serrated spurs from the ectoconelets, with reduced contiguous mesoconelet; (2) three to four conelets on worn inner lobes; (3) traces of cement in two anterior median valleys; (4) third inferior molar with well-developed pentalophid, crown relatively elongate and narrow (ap. 184 mm., tr. 80 mm., index 43), as compared with corresponding r.M_3 of *Mastodon americanus* (Amer. Mus. 21920, ap. 181 mm., tr. 93 mm., index 51) and with the large Shawangunk cranium (Amer. Mus. 2595, ap. 155 mm., tr. 84 mm., index 54). (5) This molar

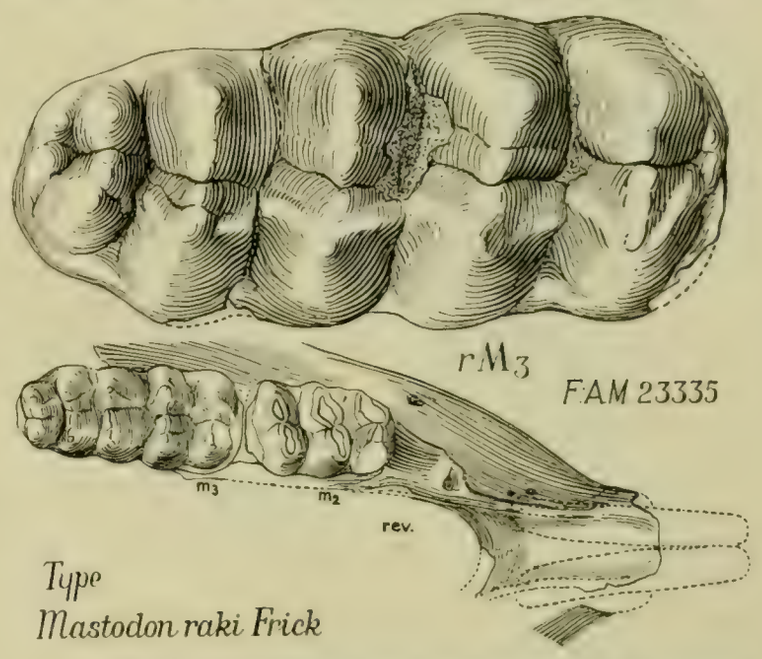


Fig. 122. (Upper) Type third right inferior molar, r.M_3, distinguished by the unusual prominence of the trefoil crests extending down the slopes of the ectoconelets (see 5 below). After Frick, 1933, fig. 25A. About one-half natural size.

(Lower) "Right ramus and symphysis and part of left ramus with m_2-m_3 [rev.]." After Frick, 1933, *op. cit.*, fig. 29A. About one-sixth natural size.

TABLE OF COMPARATIVE MEASUREMENTS OF THE MASTODON RAKI TYPE AND THREE EASTERN SPECIMENS OF MASTODON AMERICANUS

	Mastodon raki Type F:A.M. 23335 New Mexico	*Mastodon americanus* A.M. 21920 New York	A.M. 17771 Indiana	A.M. 2595 'Shawangunk' New York
m_1		88 mm.		77.5+ mm.
m_2	114 mm.	113	114	103
m_3	184	181	180	155
Width at 2d crest	80 (crown tall)	93 (crown low)	96	84
Mandible, length	800e			
Diameter of tusk	45			

with serrated ectoconelets and small mesoconelet appears to be distinct from the "*losange*" form prevailing in *Mastodon americanus*.

Geologic Age.—Frick (*op. cit.*, p. 630) observes: "The mandible was collected by Joseph Rak in the fall of 1927 from beds bearing teeth of Pleistocene *Equus*."

Mastodon americanus alaskensis Frick, 1933

Figure 123

From the vicinity of Fairbanks, Alaska. Pleistocene.

The specimen is especially interesting and important because of the rarity of the Mastodon in Alaska. Frick observes (p. 631): "*Mastodon* itself so far has been exampled in the Fairbanks area alone by a few detached molars. As associated remains of any of the extinct forms are almost unknown in the particular area, the present season's find of a mastodon mandible associated with m^3, superior tusk and a representation of the limb elements, is remarkable."

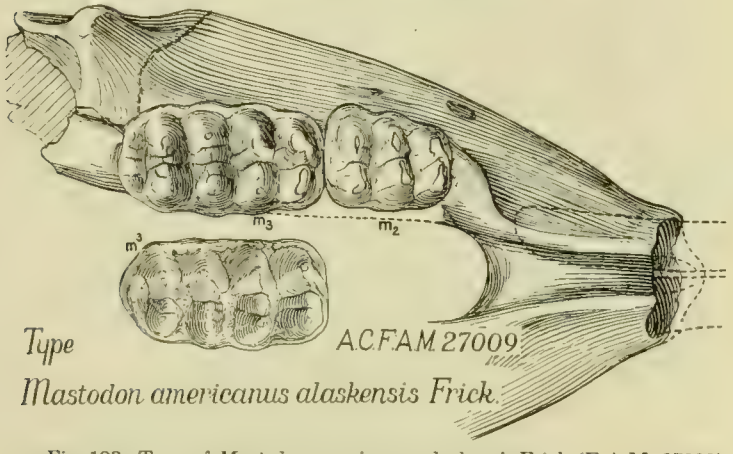


Fig. 123. Type of *Mastodon americanus alaskensis* Frick (F:A.M. 27009), about one-sixth natural size.

Left ramus and symphysis, also left third superior molar, l.M^3. After Frick, 1933, fig. 29A.

Mastodon americanus alaskensis Frick, 1933. "New Remains of Trilophodont-Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, pp. 506, 510, 631, 632. Type.—(*Op. cit.*, p. 631): "Partial mandible with left m_2, both m_3s, partial

Comparative Measurements

	M. a. alaskensis A.C.–F:A.M. 27009	*M. americanus* A.M. 14345	*M. americanus* A.M. 9951
m_2	109+mm.	123	
m_3	187 [ap.]	196 (left)	
	[101 tr.]	(176, right)	
Humerus	905		910
Radius	680		670
Ulna	675		
Metacarpal 1	107		110
2	148		150
3	175		160
4	152		150
5	123		100

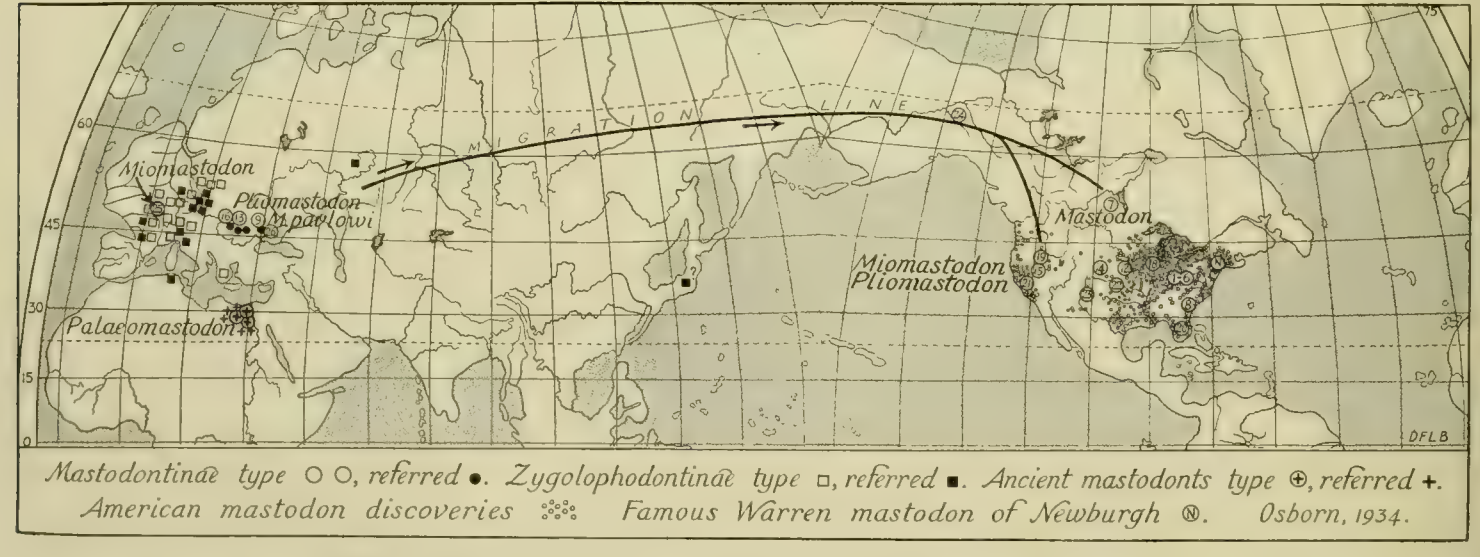


Fig. 123a. Theoretic Migration Lines of the Typical Mastodon of America

"Yoke-crested" mastodonts (subfam. Zygolophodontinæ, gen. *Zygolophodon*, *Turicius*) indicated by squares: □ types, ■ referred. Compare figure 137.

True mastodonts (subfam. Mastodontinæ, gen. *Miomastodon*, *Pliomastodon*, *Mastodon*) indicated by circles: ○ types, ● referred. Compare figure 86.

Ancient mastodonts (order Mastodontoidea, gen. *Palæomastodon*) indicated by crosses: ⊕ types, + referred.

Miomastodon tapiroides americanus, Tasnád, Hungary.

Miomastodon depereti sp. nov., Chevilly, France.

Pliomastodon americanus praetypica, Maria-Theresiopel and Batta-Érd, Hungary.

'*Mastodon ohioticus*,' Pestchana, Podolia, Russia.

Mastodon pavlowi sp. nov., Pestchana, Podolia, Russia.

Zygolophodon, chiefly distributed in Italy, North Africa, France, and Hungary. *Zygolophodon* (?) (Matsumoto), Japan.

Mastodon tapiroides (Pallas, 1770–1777), Belaja, Russia [=*Zygolophodon borsoni*].

Mastodon abundant in former forested regions of North America. See figure 123b.

Miomastodon and *Pliomastodon* rare in western United States. See figure 123b.

alveolus of m_1 and incisive alveoli; left m^3, superior tusk, humerus, both radii, ulnæ, manus, and distal end of femur. Alaska College —F:A.M. 27009. Figured this paper, *Fig. 29A.*" HORIZON AND LOCALITY.—Vicinity of Fairbanks, Alaska. TYPE FIGURE.—*Op. cit.*, fig. 29A.

TYPE DESCRIPTION.—(Frick, 1933, pp. 631, 632): "The mandible exhibits a heavier vertical ramus and symphysis and narrower symphysial trough, the alveoli suggest much larger incisors, and the molar tooth-crowns are lower than in the American *Mastodon*, as seen in A. M. 14345, from Illinois. The limbs approximate those of the Warren mount [Amer. Mus. 9951]. The tusk measures 7 ft. 1 in. on curve, and 19.5 in. circumference at base.

Osborn, 1933: The type mandible of *Mastodon americanus alaskensis* reveals (Fig. 123) relatively broad third inferior grinders, namely, $l.M_3$, ap. 187 mm., tr. 101 mm., index 54; (2) the mandible is correspondingly massive, as well as the rostrum. Another feature, also observed in *Mastodon raki* Frick, is the serration of the ectoconelets and relative reduction of the contiguous mesoconelet. Frick observes (*op. cit.*, p. 631) that "The individual, while of as large size as the Warren Mammoth [Mastodon], was immature, the epiphyses being unconsolidated."

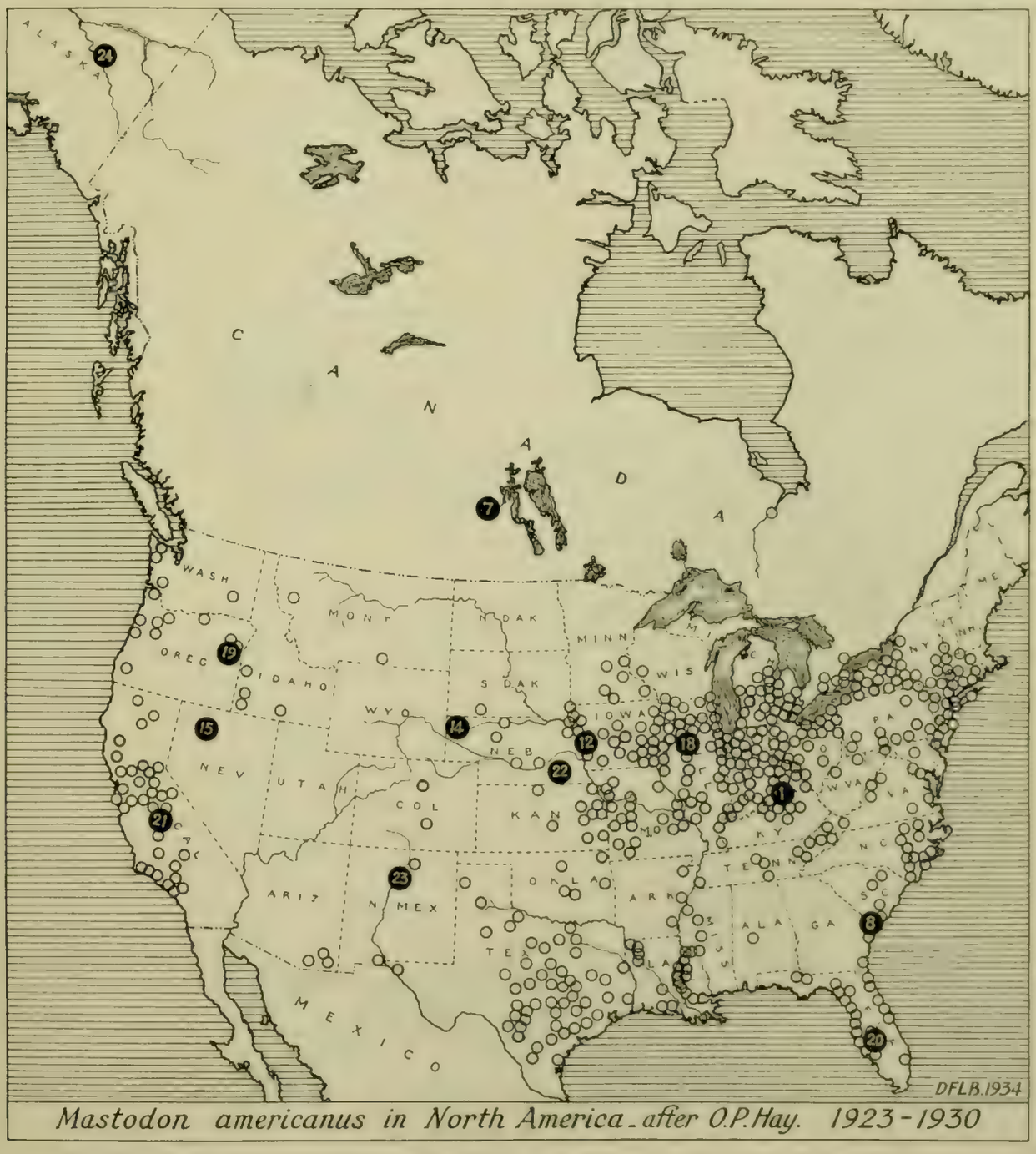


Fig. 123b. GEOGRAPHIC DISTRIBUTION OF THE TYPICAL MASTODONTS OF THE UNITED STATES AND CANADA

(1) Type locality of *Mastodon americanus* Kerr-Cuvier. (7)-(24), see full list of species on page 137.

○ Geographic distribution of subspecies and mutations of *Mastodon americanus* in the United States and Canada, after detailed reports and researches of O. P. Hay on the mastodonts of the Eastern, Middle, and Western United States, and Eastern Canada.

SKELETON OF THE WARREN MASTODON, MALE, ABOUT THIRTY-ONE YEARS OF AGE, IN THE AMERICAN MUSEUM OF NATURAL HISTORY
ESTIMATED SHOULDER HEIGHT 9 FEET 2 INCHES IN THE FLESH

Amer. Mus. 9951, one twenty-fourth natural size

Fig. 124. Mounted for the American Museum, under the direction of Curator Henry Fairfield Osborn, July, 1907, by chief preparator Adam Hermann and assistants.

Despite its long and checkered history, the skeleton is so complete that the only bones which required restoration or replacement were the following: Twenty-six caudals, namely, caudals 1–14, 16–28; the terminal phalanges of the left forefoot, except the terminal phalanx on digit III and phalanx 2 on digit IV of the right forefoot; two posterior sternal bones; phalanx 2 on digits II, III, and V. These latter bones were introduced from other individuals, namely, the two posterior sternals and phalanx 2 on digits II, III, and V.

11. SKELETAL CHARACTERS OF THE WARREN AND WHITFIELD MASTODONS

The 'Warren Mastodon' (Mastodon americanus) Skeleton

See figures 82, 83, 124, 126, and 130

Hudson River near Newburgh, New York, Pleistocene, of Postglacial (IV), or post-Wisconsin age

Every bone of this superb skeleton has been separately figured and described with great accuracy in the two editions of Warren's great Memoir (1852, 1855). The reader is referred to Warren's Memoir for all details, except those relating to the tusks which are fully described below in the present Memoir.

A full history of the discovery in the summer of 1845 of this famous skeleton and of the various phases in its mounting and exhibition is given below (pp. 181–183). In 1906 the skeleton was presented to the American Museum by Mr. J. Pierpont Morgan, to whom this Memoir is dedicated. The entire year (1906–1907) was devoted to the work of cleansing, renewing, and remounting the skeleton; all the bones were given an alcohol immersion to remove the dark varnish with which they had been covered, thus the beautiful original light brown color at the time of discovery was completely regained. The tusks had been completely shattered and were restored with great difficulty; twenty-three inches of each tusk are inserted in the sockets, the projecting part measures 6 feet 8 inches, as shown in figures 124 and 126.

Measurements of the Warren Mastodon (Mastodon americanus) compared with those of the African Elephant "Jumbo"[1] (Loxodonta africana oxyotis)

	Mastodon americanus			*Loxodonta africana oxyotis*		
Total length of skeleton, base of incisive tusks to perpendicular drop of tail	4.546	14 ft.	11 in.	4.090	13 ft.	5 in.
Height to summit of dorsal spines opposite summit of scapulæ	2.78	9	1½	3.150	10	4
Summit of scapulæ from the ground	2.635	8	8	3.045	10	
Summit of highest part of pelvis or ossa innominata from the ground	2.668	8	9	2.785	9	2
Incisive tusks: total length of right tusk on outside curve	2.615	8	7	.....	..	..
Incisive tusks: length of right tusk as exposed	2.033	6	8	.....	..	..
Thigh bones: length of right tibia	.71	2	4	.788	2	7
length of right femur	1.06	3	4¾	1.258	4	1½
length of right pes extended	.53	1	9 (on ground)	.217		8½
pelvis, width of ossa innominata	1.826	6		1.340	4	7⅛
Shoulder girdle and forelimb: height of scapula	.916	3	¼	.900	2	1
right humerus, length of	.950	3	1½	1.091	3	7
right ulna-radius, length of	.658	2	2 (ulna without olecranon)	1.037	3	4½
right extended manus, length of				.285		11¼ (without carpus)
Seven cervical vertebræ, length of	.51	1	8	.550	1	10
Dorsolumbar vertebræ, total length of	2.250	7	4½	2.035	6	8
Five sacral vertebræ, total length of	.48	1	6½	.268		10½ (length 4 sacral vertebræ)
Caudal vertebræ, estimated total number (28), total length of	2.085	6	10	1.455	4	9 (est. 21 caudal vertebræ)

[1]Amer. Mus. Dept. Mam. 3283. Prepared from specimen presented by P. T. Barnum in the year 1889.

SKELETON OF THE WHITFIELD MASTODON, ONE TWENTY-FOURTH NATURAL SIZE. FRANKFORT MUSEUM, GERMANY

Fig. 125. Mounted skeleton of the Whitfield Mastodon, an adult male, discovered in 1879, about nine miles south of Newburgh, New York, regarded by Professor R. P. Whitfield at that time as the most perfect of the mounted skeletons then known with the exception of the famous "Warren Mastodon" found near Newburgh in 1845.

REPLACEMENT.—The parts which were missing owing to decomposition were replaced from other individuals as follows: (1) Tusks found at Hoopston, Illinois, both belonging to the same individual as a separate lower jaw with two tusks. (2) Pelvis and three ribs from Hangman's Creek in Oregon.

RESTORATION.—All phalanges except No. 1 on digit IV of the right forefoot; all phalanges and pisiform of left forefoot; all digits except metatarsals III and V and two cuneiforms of the right hindfoot; all phalanges of digits I and V, and two cuneiforms of the left hindfoot; four vertebræ of the neck, three of the back, and all vertebræ of the tail below the sixth vertebra; a portion of the right shoulder blade.

On the acquisition by the American Museum of the Warren Mastodon skeleton (Fig. 124), the Whitfield Mastodon was transported to the Senckenberg Museum of the city of Frankfort, Germany.

The contrast between the comparatively broad, long-backed, low-bodied proportions of *Mastodon americanus* and the elevated, short-backed, narrow-bodied proportions of the African elephant is similar to that which generally obtains as between the Mastodontoidea and the higher Elephantoidea.

MASTODONTOIDEA: Relatively broad, low-bodied, heavy-limbed, long-backed proboscideans.
ELEPHANTOIDEA: Relatively narrow, high-bodied, long-limbed, short-backed proboscideans.

The 'Whitfield Mastodon' (Mastodon americanus) Skeleton

Hudson River, near Newburgh, New York, Pleistocene, probably of Postglacial (IV) or post-Wisconsin age

The Whitfield Mastodon (Fig. 125), named in honor of the late Curator Robert Parr Whitfield of the American Museum, is the assembled skeleton of a male mastodon in which the tusks are of a large size, but the proportions and mounting are much less accurate. This skeleton, mounted for the American Museum in 1879, was purchased by the Senckenberg Museum of Frankfort, Germany, where it is now on exhibition.

History.—(1) This skeleton was discovered in 1879 near the town of Little Britain, about nine miles south of Newburgh, N. Y. It was imbedded in peaty material on the edge of what had been less than fifty years before an open pond; the pond had been drained and was under cultivation at the time of discovery. In course of further drainage work, following the wet season of 1879, at a depth of fourteen inches, an apparent log was reached, which proved to be the leg bone of an animal. This induced the farmer to search for other bones, and in a few days more than one-third of the skeleton had been exhumed, including the head and lower jaws. (2) Three weeks later Professor R. P. Whitfield, first Curator of Geology in The American Museum of Natural History, visited the excavation at the request of Major T. B. Brooks of Newburgh. He found that the swamp on the side nearest the skeleton was bordered by a low hill of hard blue "boulder clay," mixed with shale and gravel. This hard layer sloped down and passed under the peat or "muck" of the swamp to form the original bottom of the pond. From this peat the skeleton derived its dark color. (3) The skeleton lay with the head farthest from the original shore of the pond and deeply imbedded. The right limbs were near the surface, the right humerus being buried only fourteen inches, which proves apparently that the animal had been mired and had fallen on its left side. At the point where the head was found, twenty feet from the place at which the "boulder clay" rose to the surface, the peaty material had accumulated over the head to a depth of ten feet. The humerus and other parts nearer the surface were consequently less perfectly preserved.

12. AGE AND PROGRESSIVE CRANIAL AND DENTAL CHARACTERS OF MASTODON AMERICANUS, REVEALED IN THE AMERICAN MUSEUM COLLECTIONS

Superior and inferior grinders, incisive tusks, age, sex, growth, cranial and mandibular development

Age and Sex Characters of the Incisive Tusks

In the assemblage and preparation of the tusks of the Warren Mastodon skeleton (Amer. Mus. 9951), Osborn (1910.347 and 1923.574) made the following observations which should be permanently recorded in this Memoir:

A Means of Estimating the Age of the Mastodon.—(Osborn, 1910.347, pp. 1–3): In repairing the tusks, the outer sheathing of the dentine was found in large part absent. The inner sheathing exposed a series of concentric constrictions and expansions which were observed to be approximately symmetrical on the two sides, as indicated by the series of + signs in Fig. 3, A and B [Fig. 126, right, of present Memoir]. Secondly, it was noted that the intervals between these constrictions are broader in the middle and fore part of the tusks (corresponding with the youthful stage of growth of the tusk) and become narrower

toward the base of the tusk (corresponding with the mature or adult stages of growth). Eighteen of these rings are preserved on one side and thirteen on the other. They are faintly indicated also in the waving surface of the dentine of the tusk (Fig. 3). On the hypothesis that these are actual annular increments of growth, the right tusk (Fig. 3, A) consisted of about twenty-eight segments, which allowing for the milk dentition and for the part worn off at the tip would assign to the Warren Mastodon an age of perhaps thirty years. Similar annular constrictions are observed in the tusks of the mammoth from Alaska; and are also indicated in the tusks of the African elephant. Since the age of the Indian elephant and the rate of tusk growth is definitely known, the identification of similar concentric annular growths would be the means of testing the value of this hypothesis.

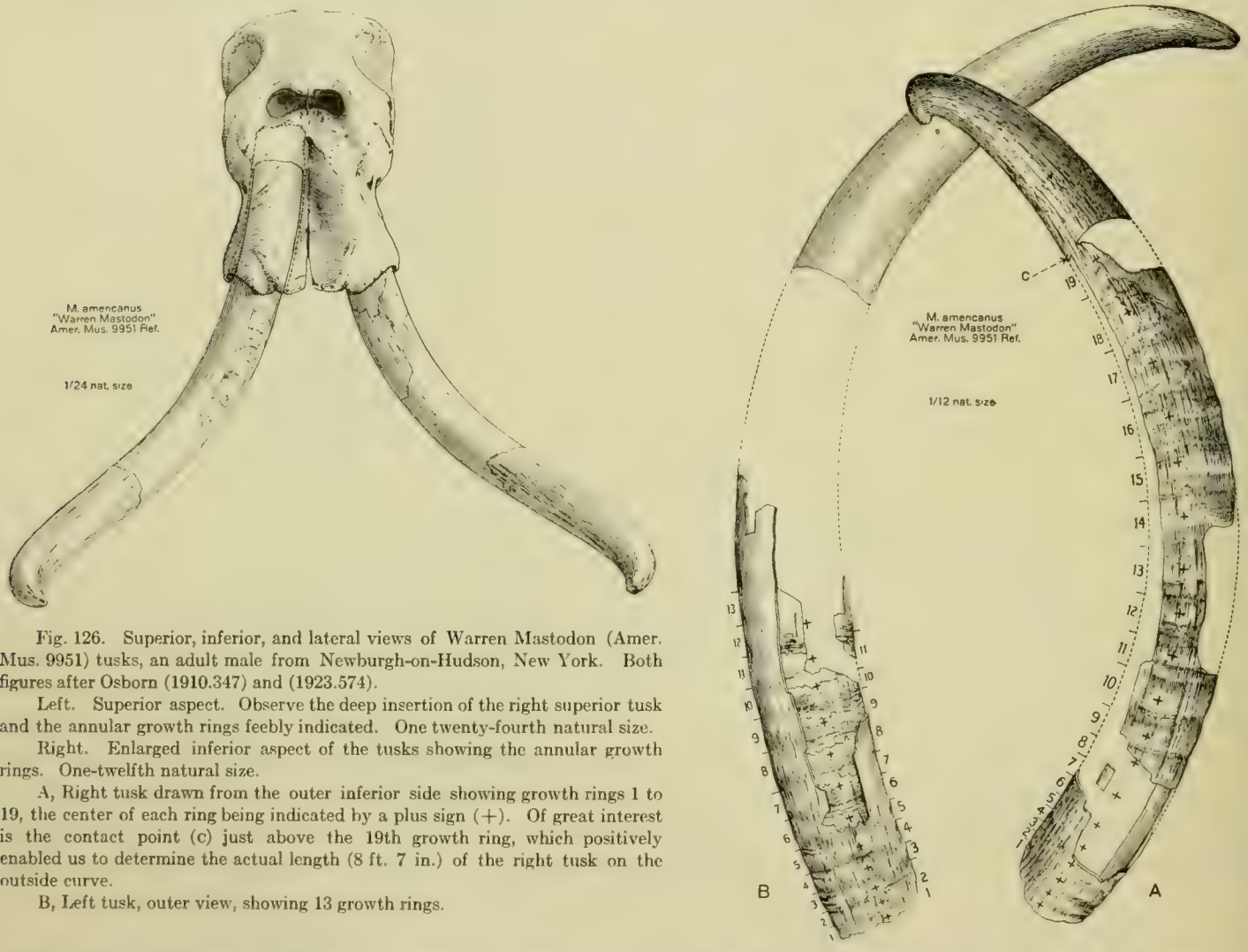


Fig. 126. Superior, inferior, and lateral views of Warren Mastodon (Amer. Mus. 9951) tusks, an adult male from Newburgh-on-Hudson, New York. Both figures after Osborn (1910.347) and (1923.574).

Left. Superior aspect. Observe the deep insertion of the right superior tusk and the annular growth rings feebly indicated. One twenty-fourth natural size.

Right. Enlarged inferior aspect of the tusks showing the annular growth rings. One-twelfth natural size.

A, Right tusk drawn from the outer inferior side showing growth rings 1 to 19, the center of each ring being indicated by a plus sign (+). Of great interest is the contact point (c) just above the 19th growth ring, which positively enabled us to determine the actual length (8 ft. 7 in.) of the right tusk on the outside curve.

B, Left tusk, outer view, showing 13 growth rings.

The Warren Mastodon thus represents a *male* animal at least thirty years of age at the time it sank into a bed of marl near Newburgh, New York. The story of the restoration of these tusks is as follows (cf. Osborn, 1923.574, p. 18):

Method of Restoring the Warren Mastodon Tusks.—There still remained the problem of the tusks, which are invariably the most vital part of buried skeletons of the great proboscideans of the past. It appears that the original tusks could not be preserved entire by the methods known at the time of exhumation. The discoverers were unable to prevent the tusks from splitting, warping, and falling to pieces, especially at the butt. In order to preserve what could be saved intact, the butts of the tusks, already split and warped, were sawed off under Doctor Warren's direction, and only the tips, about three feet in length, were treated and preserved. The butts, fallen into fragments, but still lying undisturbed in two of the original boxes used for transporting the skeleton, were found in the Warren Museum when the skeleton was repacked to be sent to the American Museum. The tips, treated with preservatives, were still intact in another box; but neither had been used apparently for measurements in making the papier-mâché restorations fitted to the skull in the Warren Museum. This documentary evidence certainly was not used by Doctor Warren, because in his three restorations he unfortunately accepted the

erroneous original reports that the tusks as found were more than eleven feet in length; they were so described and illustrated by him in the entirely impossible position shown in the photograph on p. 15 [Fig. 83 of the present Memoir].

When the Warren collection reached the American Museum, it was very carefully looked over in a search for remnants of the original tusks, and finally the fragmentary fossil ivory tips and butts were found, but inasmuch as most of the original records had been lost and no use of these materials had been made by Doctor Warren, it remained to be proved that the fragmentary butts of the tusks really belonged with the skull. The piecing together of these butts required several months of most ingenious and patient work on the part of one of our preparators, Mr. Charles Christman. The ends of each tusk were perfectly preserved, but there was no connection between these tips and the reconstructed butts of either tusk. Fortunately, when the butts of the tusks were sawed off, a single splinter of bone broke off, and finally this splinter was found to fit exactly to a fragment of the butt. There was great rejoicing in the laboratory when the relationship of these two fragments was discovered, because it enabled us to determine positively the length of the tusks as 8 feet, 7 inches.

The rebuilding of the tusks, which required several months of most patient work, had two very important results: in the first place, it enabled us to place them properly in the sockets of the skull and to prove for the first time the exact relations of the mastodon ivories; secondly, a very painstaking examination of these tusks led to an important and most interesting discovery, namely, that it was possible to determine very closely the age of the Warren Mastodon. The ivory exhibits a series of growth rings which, counted from tip to base, seems to prove that the Warren Mastodon was perhaps thirty years of age at the time it sank into the bed of marl near Newburgh. The right tusk included at least twenty-eight of these segments. The growth rings are shortest near the tip of the tusk when the animal is young, and increase in length from the tip toward the middle of the tusk, but not in a regular ratio. These growth rings do not correspond exactly in the opposite tusk, but in both tusks they are longest in the middle region. Nine smaller rings are in the lower part. The writer's theory regarding these growth rings is that during the summer season, when all the conditions of life were favorable, and perhaps during the rutting period, when tusk growth was hastened by internal secretions from the reproductive glands, the growth of ivory was very rapid, the maximum growth in the 17–18 ring being 108 centimeters, or 4¼ inches, perhaps the maximum growth of a favorable season at the most vigorous reproductive period of life. The Warren Mastodon is an adult but not an aged specimen; the skeleton is apparently that of a younger animal than the one represented by the Shawangunk head. Some estimate the maximum age of the American mastodon at between thirty and forty years,—less than half the life span of the elephant, which attains more than one hundred years.

Male and Female Tusks.—In all the known Proboscidea there is a marked disparity between the male and female incisive tusks both in length and in diameter. The adult female tusks never fully attain the length of the adult male tusks, but a still more striking difference is their slenderness of proportion and diameter.

The *female* tusks are finely displayed in the female skull of *Mastodon americanus* (Amer. Mus. 14293) found near Fulton, Indiana, and represented one-tenth natural size in figure 128. We observe that the *divergence* of the tusks in their sockets produces the strikingly V-shaped arrangement of the grinding teeth and the tusks, so that a straight line drawn from the apex of the tusks traverses the grinders and passes through the occipital condyle of the opposite side; this explains the marked divergence of the grinding teeth anteriorly, and the convergence of the grinding teeth posteriorly. Undoubtedly the incisive tusks were extremely important in females for the defense of the young, and this strongly divergent tusk mechanism brought about a strongly divergent grinding tooth mechanism. This divergence, however, is much less marked in the *male* skull (Yale Mus. 12600), beautifully represented in figure 129, than in the Warren Mastodon skull (Fig. 130).

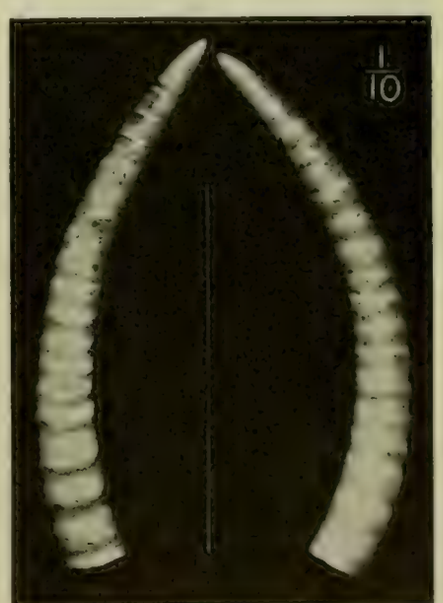


Fig. 127. Tusks of *Elephas indicus* (?) *sumatranus* showing 17-18 annular growth rings. After photograph kindly furnished by Mr. H. Munniks de Jongh of the Hague, who purchased them some years ago without a record. It is probable that they are from the Dutch East Indies. One-tenth natural size. (Cf. Fig. 126.)

Male and Female Crania.—The palatal aspect (Fig. 129) of the superbly preserved adult skull of the *Mastodon americanus* from Otisville, New York, in the Peabody Museum of Yale University (Yale Mus. 12600), is shown one-eighth natural size. The drawing is one of the masterpieces of

Mrs. L. M. Sterling, the artist of most of the original pen illustrations in this Memoir. All the constituent bones and the foramina are clearly indicated by abbreviations, as lettered under the direction of Dr. William K. Gregory. Viewed both from above (Fig. 130) and below (Fig. 129) the *facial* and *cranial* portions of the *M. americanus* cranium are subequal in length. There is a very marked development of the premaxillaries (*P. mx.*) and of the maxillaries (*Mx.*), an abbreviation of the palatines, a compression and an abbreviation of all the basicranial elements, which, however, are much less extreme than in the basicranial aspect of the Indian elephant (*Elephas indicus*), see Volume II, Chapter XX.

Fig. 128. Female skull. Palatal view of the finely preserved female skull (Amer. Mus. 14293) of *Mastodon americanus* from near Fulton, Indiana. One-tenth natural size.

Observe the strikingly **V**-shaped arrangement of the grinding teeth and tusks, the apex of the **V** being at the posterior nares. The tusks are relatively long, very slender, gently convex or outcurved, and slightly incurved at the extremities.

The *male* cranium (Amer. Mus. 14535) represented in figure 132 differs strikingly from the Peabody Museum cranium (Yale Mus. 12600, Fig. 129) in the fact that the facial portion, from the premaxillaries to the back of the grinders inclusive, is decidedly longer than the cranial portion; it differs also in the marked divergence of the grinding teeth of the opposite sides, whereas in the Peabody Museum skull (Yale Mus. 12600) the grinding teeth are more nearly parallel.

The *female* cranium (Amer. Mus. 14292) represented in figure 132 shows a very marked sexual disparity in size; this is probably the normal disparity between the male and female crania of *Mastodon americanus*, because this female cranium does not differ markedly from the female cranium (Amer. Mus. 14293) shown in figure 128. The more feeble and slender female tusks (Fig. 128) demand less prominent premaxillo-maxillary development, consequently the sockets for the incisive tusks are relatively short and small, and elevated above the grinding tooth border, as seen in both the female skull (Amer. Mus. 14293, Fig. 128) and in the female skull (Amer. Mus. 14292, Fig. 132). Thus there is a marked disparity in size between the females and males in (1) the grinding teeth, (2) the incisive tusks, (3) the sockets of the incisive tusks, and (4) the size of the cranium as a whole.

Juvenile Male Crania.—The fully adult age characters pointed out in the above descriptions

and figures of the *male* and *female* skulls should be compared with the juvenile and infantile characters of the immature male crania shown in figure 131. The immature male skull[1] (Amer. Mus. 17727, Fig. 131 A1), from Rochester, Indiana, represents a stage in which the three 'intermediate molars' only are in use, namely, Dp 4, M 1, M 2. All these teeth show the three transverse crests characteristic of this genus and species. The tetralophodont third superior and inferior molars, M^3-M_3, have been extracted from the skull and jaws and are repre-

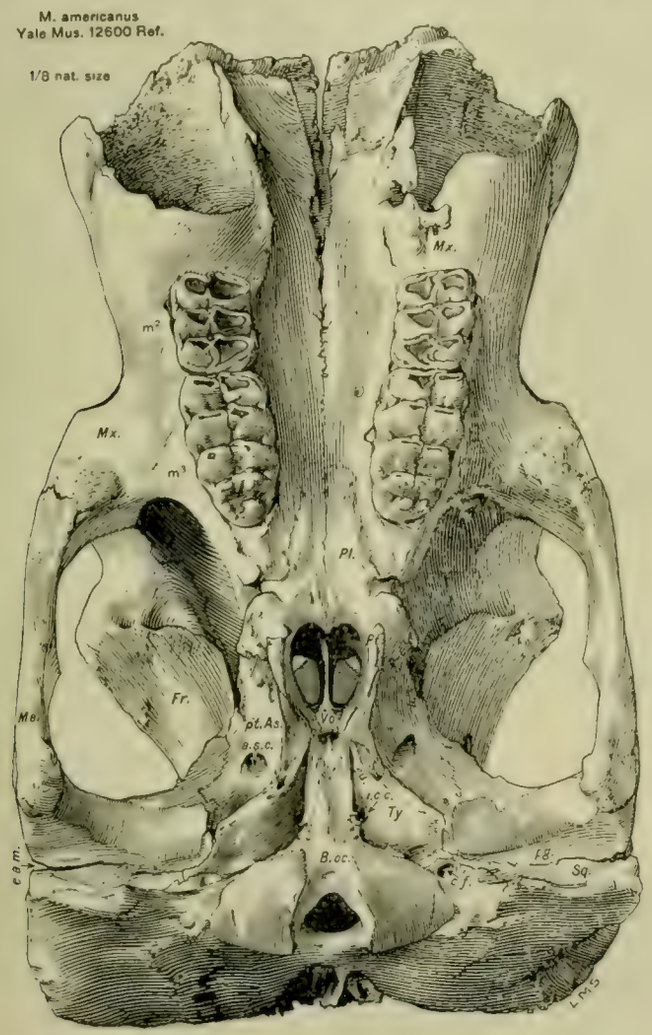


Fig. 129. *Mastodon americanus* palate of finely preserved adult skull (Yale Mus. 12600), from Otisville, New York. One-eighth natural size. Complete skeleton collected May 7, 1875.

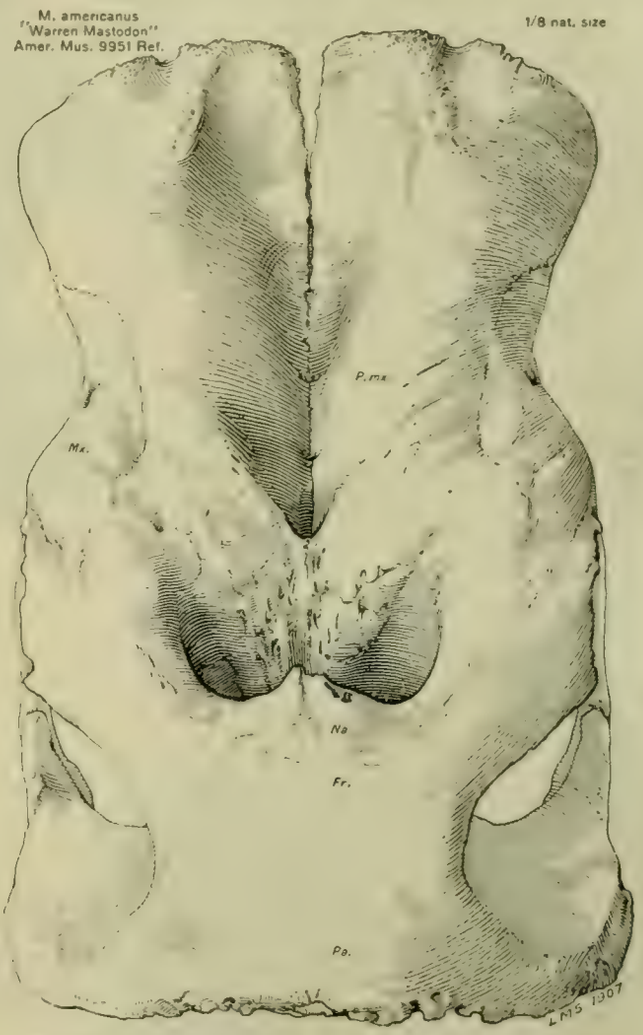


Fig. 130. Superior view of skull (Amer. Mus. 9951) of the "Warren Mastodon," an adult male with the tusks removed. One-eighth natural size.

sented in figure 135. In this young male cranium[1] (Amer. Mus. 17727) we observe the following points: (1) The facial and cranial portions are subequal in length; (2) the sides of the cranium are nearly parallel; (3) the juvenile tusks are imbedded in slightly expanded premaxillary sockets; (4) all the crests of the grinding teeth (Fig. 131 A1, also Fig. 135) are extremely sharp, representing a high degree of subhypsodonty.

The calf skull of *Mastodon americanus* (Fig. 131 B) found near Hackettstown, Warren County, New Jersey, about twenty miles from Newark, represents a much more immature stage (Amer. Mus. 10459).

Immature and Mature Grinding Teeth.—The immature male skull[1] from Rochester, Indiana (Amer. Mus. 17727, Fig. 131 A1) yields a series of immature dental crests (represented in Fig. 135) of the third left superior molar, l.M^3, and of the third left inferior molar, l.M_3. These ridge-crests are a revelation of the very sharp,

[1]This specimen is now made the type of *Mastodon acutidens* (see Appendix at the close of the present Volume, also Figs. 131, A1–A4, 135, and Pl. 1, L, of this chapter).

Fig. 131. (A1–A4) Type of Mastodon acutidens sp. nov.; compare Figure 135. (B) Immature male skull of M. americanus Ref. One-eighth natural size. American Museum Collection, Nos. 17727,[1] 10459.

A1, Left lateral, A2, superior, A3, palatal, A4, occipital views of young Mastodon skull (Amer. Mus. 17727),[1] from Rochester, Indiana, showing Dp^4, M^1, and M^2, anterior portion only in use. M^3-M_3, extracted from the skull and jaws, shown in figure 135. Type of *Mastodon acutidens* sp. nov.

B, Calf *Mastodon americanus* skull (Amer. Mus. 10459), superior view. Found near Hackettstown, Warren County, New Jersey, about twenty miles from Newark.

[1]See footnote on page 185.

Fig. 132. Male and Female Crania of Mastodon americanus

(Left). Male cranium of *Mastodon americanus* viewed from above and from the side; also palatal view. This is a young adult cranium (Amer. Mus. 14535), from Ashley, Indiana. One-twelfth natural size.

(Right). Female cranium of *Mastodon americanus*, of somewhat greater age than the male cranium, exhibiting similar aspects of the skull. This cranium (Amer. Mus. 14292) was discovered two and a half miles southeast of Fulton, Indiana. One-twelfth natural size.

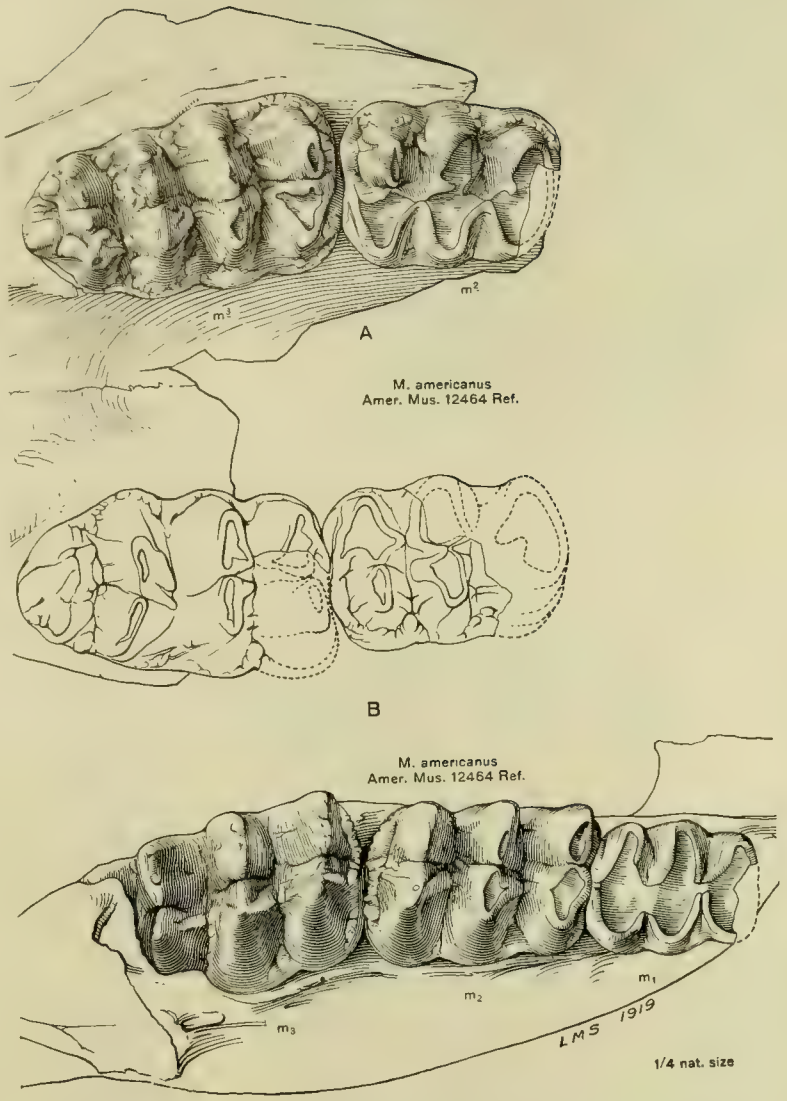


Fig. 133. Typical grinders. Crown view of male (?) palate and lower jaw of middle-aged individual of *Mastodon americanus* (Amer. Mus. 12464), from Buffalo, Kansas. One-fourth natural size.

Observe: (1) Characteristic double lobes in upper and lower molars; inner superior and outer inferior lobes expanding into trefoils near median sulcus (see A, M^3, M^2); (2) also internal and external cingula in M^3, and (3) posterior and anterior cingula between M_2 and M_3.

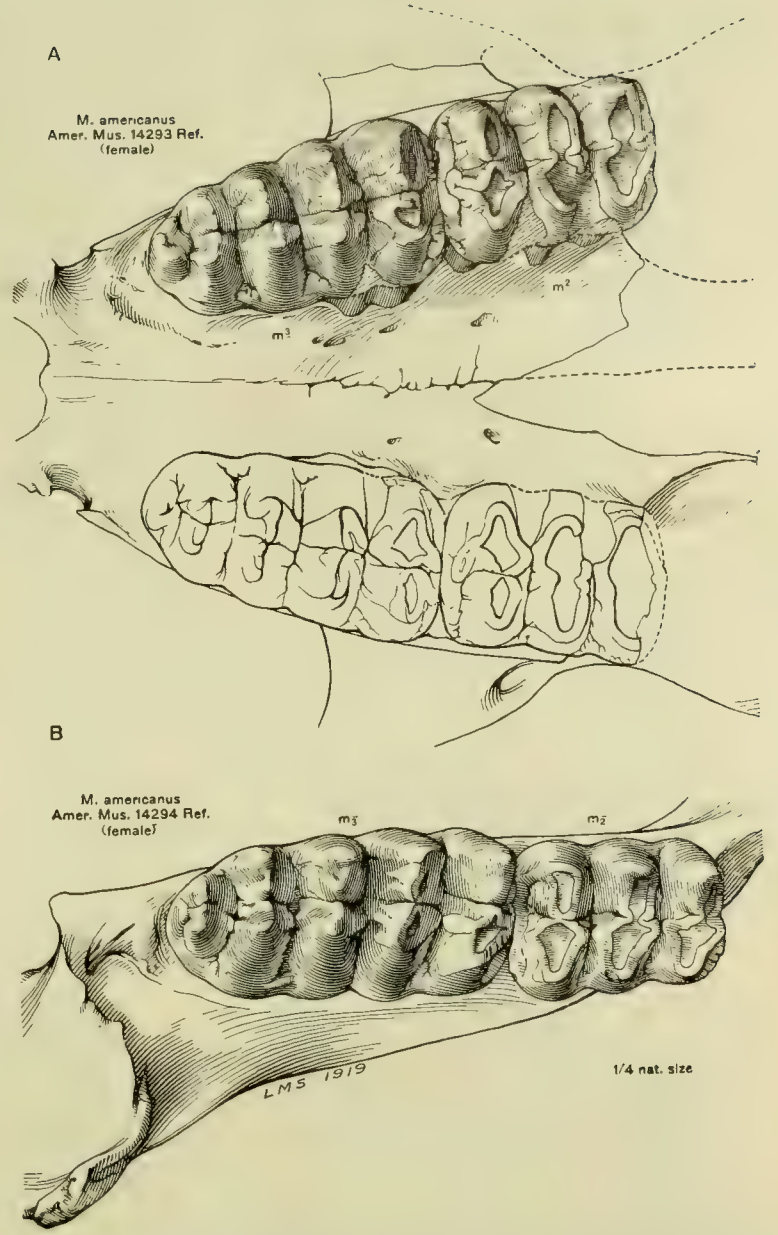


Fig. 134. Middle-aged *female* palate and lower jaw of *Mastodon americanus* (Amer. Mus. 14293 and 14294), from near Fulton, Indiana. One-fourth natural size.

Observe in M^2 and M_2 *rudimentary trefoil spurs* on *inner* side of superior molar and on *outer* side of inferior molar, conforming to the reversal of upper and lower trefoils observed in all the Longirostrines.

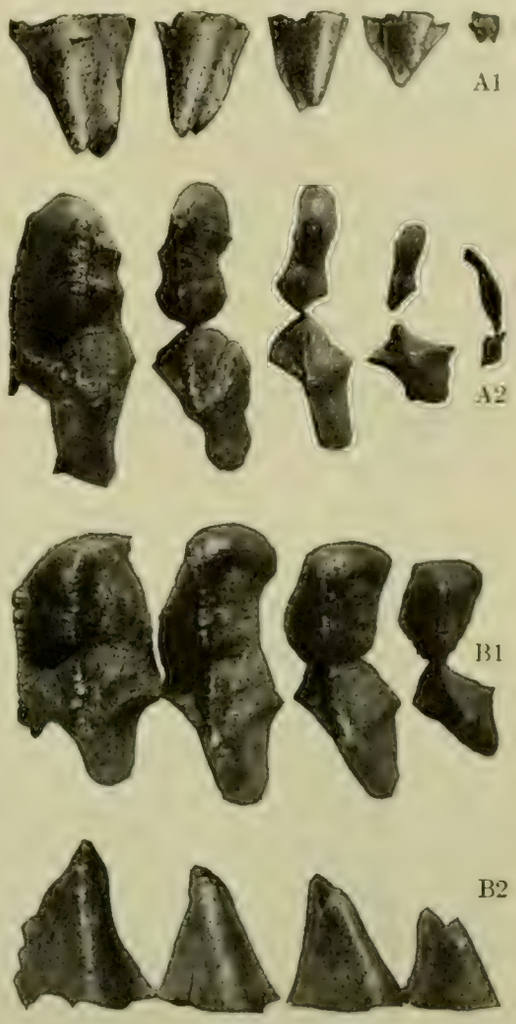
almost knife-like summits of the molar ridge-crests, which give a truly *subhypsodont* character to these crowns. These sharply crested summits illustrate the very marked progression of *Mastodon acutidens* sp. nov. upon the low, compressed crowns in the two species *Miomastodon merriami* and *Pliomastodon matthewi*, and upon the rounded lobes, i.e., cones, in *Palæomastodon*.

Hypsodont Grinders.—It is probable that when all the grinding teeth now referred to *Mastodon americanus* are carefully measured and compared, considerable progressive evolution toward *hypsodonty* will be observed through the long period of Pleistocene time.

Much more sharply elevated and acute transverse crests than those of the *female* specimens found near Fulton, Indiana, and represented in figure 134, are the grinders of the young male (Amer. Mus. 17727, Fig. 135), the type of *Mastodon acutidens* sp. nov.

Typical Grinders.—The typical female grinders (Amer. Mus. 14293 and 14294, Fig. 134) exhibit relatively obtuse crests both in the upper and lower jaws. It may be observed also: (1) That the individual lobes, i.e., cones, are not distinctly bilobed; (2) that the worn enamel presents simple, compressed loops in M^2-M_2; (3) that the trefoil spurs rise from the *internal* lobes of M^2, from the *external* lobes of M_2; (4) that a sharp median sulcus divides the internal lobes from the external in M^3-M_3. It is not surprising that these rudimentary *trefoil spurs* should be compared with the homologous trefoils of *Trilophodon* and of *Serridentinus;* in position they resemble *Serridentinus* rather than *Trilophodon.* (5) The third inferior molar, M_3, is distinctly longer and relatively narrower than the third superior molar, M^3. These beautifully drawn grinding teeth very clearly illustrate the characters of the typical *Mastodon americanus* and agree closely with Cuvier's type grinders (Figs. 76, 112) from the Big-Bone Lick, near the Ohio River, Kentucky.

Plicated Grinders.—A somewhat more folded or plicated condition of the superior grinders is shown in the palate and lower jaw (Amer. Mus. 12464, Fig. 133) of a middle-aged male (?) individual of *Mastodon americanus* found near Buffalo, Kansas. These plicated or folded grinders approach those of the type of *Mastodon americanus plicatus* Osborn (Fig. 120), although the plication is somewhat less extreme. We observe in M^3 (Fig. 133 A) the marked development of the *cingulum*, internal, anterior, and external, and the marked irregularity of the enamel surfaces of the lobes; the tetartoloph in M^3 is subdivided into four conelets; in M_3 there is a strong anterior cingulum, but it exhibits no external or internal cingula.



Type of Mastodon acutidens sp. nov.

Fig. 135. Sharp summits of partly developed molar crowns excavated from a young male skull (Amer. Mus. 17727), from Rochester, Indiana. Compare figure 131, A1–A4.

A1, Five crested left superior molar, l.M^3, external view.

A2, Crown view of the same five crests of l.M^3. Observe the division of the transverse crests into inner and outer lobes, completely separate in the young condition.

B1, Crests of undeveloped left lower molar, l.M_3, somewhat more advanced than the upper. Observe the bilobed condition of the fourth crest; fifth crest not developed.

B2, External view of same crests of l.M_3. Observe the high anteroposterior compression of these crests adapted to the sharp cutting of the food.

We conclude that the male and female grinding teeth of specimens from different parts of the United States, mostly of Upper Pleistocene and Postglacial time, exhibit marked progressive ascending mutations and subspecific characters which may be found to distinguish more or less constantly the descendants of certain subspecific, specific, and phyletic branches.

Summary of Sexual and Progressive Characters Observed in the American Museum Collections

In the American Museum materials referred to *Mastodon americanus*, it is clear from the above brief descriptions and from the close examination and comparison of the carefully prepared figures that there is a *very marked progressive evolution* in the grinding teeth, and probably in the tusks and portions of the skeleton as well, indicating varied ascending mutations and *subspecific* if not *specific* stages. These characters are not mere individual variations; they certainly mark progressive evolution extending over a very long period of time, namely, over the entire 1,000,000-year period, the minimum figure now assigned to the American Quaternary or Pleistocene time.

(1) The primitive species *Mastodon progenius* Hay is believed to be of Aftonian or *1st Interglacial* age.

(2) The *Mastodon americanus* of Big-Bone Lick, Kentucky, is of much more recent geologic age, probably IV Glacial time, indicated by *Ovibos* and *Rangifer*. These are probably the typical deposits of the species *Elephas* [*Mastodon*] *americanus* Kerr, which came from the Big-Bone Lick.

(3) The 'mastodon' deposits of Newburgh-on-Hudson, New York, including the 'Warren Mastodon,' are probably of Postglacial (IV) age, or the period of the retreat of the great Wisconsin glacier.

If these geologic correlations are correct, the evolution of *Mastodon americanus* covered a period of at least 1,000,000 years, from the more primitive stages, such as *M. progenius*, to the most progressive stages, such as *M. acutidens* sp. nov. These stages, however, can only be clarified by very close and prolonged monographic research.

Group of American Mastodons along the Ancient Missouri River of Kansas

Left portion of the great late-Pleistocene mural in the Hall of the Age of Man in the American Museum. The faunal period of *Bison latifrons* (*Bison regius*) and *Equus complicatus* (*Equus scotti*)

Fig. 136. This mural, painted under the direction of Henry Fairfield Osborn, was completed by Charles R. Knight in the year 1920 and is one of the finest examples of his art. In the group there are one bull, two cows, and a calf.

Chapter VII

HISTORY OF THE SUBFAMILY ZYGOLOPHODONTINÆ, THE YOKE-TOOTHED MASTODONTS

Gradual separation of the 'mastodon' tapiroides and 'mastodon' turicensis from the 'mastodon' borsoni and other phyla of the mastodonts. Subfamily, generic, and specific distinctions of the zygolophodont genera, namely, zygolophodon and turicius. Habitat, migrations, phylogenetic succession, and extinction of the zygolophodontinæ. Comparison with stegolophodon.

1. History of the subfamily Zygolophodontinæ, 1770–1927–1935.
2. Collateral relationship to the subfamily Stegodontinæ.
3. *Zygolophodon* and *Turicius* independent phyla (Osborn, 1926) of the Zygolophodontinæ Osborn, 1923.
4. Résumé of the generic and specific distinctions.
5. Progressive characters of the grinding teeth.
6. Characters of *Zygolophodon* and its included species.
7. Characters of *Turicius* and its included species and mutations, as compared with *Zygolophodon* and *Serridentinus*.
8. Geographic distribution and extinction of species of *Turicius*.

(January, 1935) Since 1928, when this chapter was written, the fundamental patterns of the grinding teeth of *Palæomastodon, Mastodon, Zygolophodon, Turicius,* and *Stegolophodon* have been intensively examined, compared, and figured, as shown in Pls. I–IV, between pp. 134 and 135. These new comparative figures positively demonstrate: (1) The complete phyletic separation of these five genera, and (2) the possible derivation of the grinding teeth of the Stegodontoidea from those of *Stegolophodon*.[1] The species of *Stegolophodon* and of *Stegodon* are described in detail in Chapter XV of Volume II of this Memoir.

We may open this chapter by calling attention to the marked *sexual* and *progressive* characters which may be observed in the mastodonts in the American Museum collections. These serve clearly to distinguish the Mastodontinæ or true mastodonts from their most nearly related phylum the Zygolophodontinæ, because it is clear throughout that (1) the true *Mastodon* molar is profoundly different in character from the true *Zygolophodon* molar, and (2) that the final stage of evolution in the *Mastodon acutidens* molar (Fig. 135) *converges* towards the final evolution stage in the *zygolophodont* molar (Fig. 168, *Turicius virgatidens*).

This chapter covers the genera *Zygolophodon* Vacek and *Turicius* Osborn. The species included within *Turicius* show several resemblances to those included within the genus *Serridentinus* (Chap. X), as observed by the present author; in many other characters *Turicius* is clearly separable from *Serridentinus* and more closely related to *Zygolophodon*. The median longitudinal sulcus (Fig. 89) of *Mastodon americanus* disappears in *Zygolophodon* and transversely perfected crests evolve. *Zygolophodon* has four to six main conelets, *Turicius* has *five* to *eight* small conelets (*T. turicensis*) to *eight* to *nine* (*T. virgatidens*).

As pointed out clearly in the preceding and succeeding sections, the genus *Zygolophodon*, based by Vacek (1877) on the three genotypic species *Mastodon borsoni*, *M. turicensis*, and *M. tapiroides* (= *M. pyrenaicus*), now proves to include two distinct generic phyla which may be traced chiefly in western Eurasia from the base of the Miocene to the summit of the Pliocene, namely:

I. *Zygolophodon borsoni*, which may spring from *Z. pyrenaicus*, and from *Z. pyrenaicus aurelianensis*, Lower Miocene of France. This generic phylum parallels the true *Mastodon americanus* phylum in its evolution, but it is nevertheless quite distinct. Like the true mastodonts, it is little known until Middle and Upper Pliocene times, when the remains of *Z. borsoni* are very abundant.

II. *Turicius*, typified by *Turicius turicensis* of the Upper Miocene, is a very distinct generic phylum, extending from the Lower Miocene *'Mastodon' tapiroides* of Cuvier to the Middle Pliocene. This phylum is abundantly represented especially in lignitic and fluviatile deposits. It is quite distinct (see Figs. 138 C, C1; 139, 4, 5, of the present chapter) from the phylum *Zygolophodon borsoni* and presents certain parallels with the *Serridentinus* phylum, which is widely distributed in the Miocene and Pliocene of America.

[1](1935) *Stegolophodon* removed from the Stegodontinæ and placed in the new subfamily Stegolophodontinæ (see Appendix of the present Volume I).

1. HISTORY OF THE SUBFAMILY ZYGOLOPHODONTINÆ, 1770–1927–1935

Original reference: Zygolophodontinæ Osborn, 1923, "New Subfamily, Generic, and Specific Stages in the Evolution of the Proboscidea," Amer. Mus. Novitates, No. 99, p. 1 (Osborn, 1923.601).

Buffon, 1770.—The history of discovery goes back to the year 1770, when Buffon received from the Comte de Vergennes an upper grinding tooth found in Russia ("la petite Tartarie") and after examination and description figured the tooth in 1778, as shown in our facsimile reproduction (Fig. 111). Marie Pavlow (1894) refers to Buffon's description of this tooth in the "Epoques de la Nature," 1775 [1778]. Almost at the same time (1777) Pallas described a tooth found near the Belaja, an affluent of the Kama River, Russia, a tooth which subsequently Eichwald and de Blainville referred to *Mastodon tapiroides* [now referable to *Zygolophodon borsoni*]. Pavlow's full description of these Russian and Siberian discoveries is cited above (Chapter VI, pp. 133–135).

The chief succession in the discovery and description of the species of Zygolophodonts in Eurasia appears to be as follows:

CHRONOLOGIC ORDER OF DISCOVERY AND DESCRIPTION

See Figure 137

			Original Name	Specific Reference in Present Memoir	Geologic Age
	1770–1778	Russia	True zygolophodont molar, described and figured by Buffon (see Fig. 111)	= *Zygolophodon borsoni*	Pleistocene (?)
	1777	Near the Belaja, Russia	Zygolophodont molar described by Pallas	= *Zygolophodon borsoni*	Pleistocene (?)
1.	1806	Montabusard, France	*Petit mastodonte* Cuvier	= *Turicius tapiroides*	Lower Miocene
2.	1814	Montabusard, France	*Mastotherium microdon* Fischer de Waldheim	= *Turicius tapiroides*	Lower Miocene
2a.	1814	Europe	*Mastodon microdon* Rafinesque	= (?)*Turicius tapiroides*	
1.	1821	Montabusard, France	*Mastodonte tapiroïde* Cuvier	= *Turicius tapiroides*	Lower Miocene
3.	1824	Elgg, Switzerland	*Mastodon turicense* Schinz	= *Turicius turicensis*	Upper Miocene
4.	1834	Piedmont, Italy	*Mastodon Borsoni* Hays	= *Zygolophodon borsoni*	Middle Pliocene
5.	1835	Simorre, France	*M. tapiroides-minus* Lartet	= *Turicius tapiroides-minus*	
6.	1847	Vialette (environs du Puy), France	*Mastodon Vialetii* Aymard	= *Zygolophodon borsoni vialetii*	Upper Pliocene
7.	1847	Velay, France	*Mastodon vellavus* Aymard	= *Zygolophodon borsoni vellavus*	Upper Pliocene
8.	1848	Auvergne, France	*Mastodon Buffonis* Pomel	= *Zygolophodon borsoni buffonis*	Upper Pliocene
9.	1857	Pikermi, Greece	*Mastodon atticus* G. & L. (in Wagner)	= *Turicius atticus*	Lower Pliocene
10.	1857, 1859	Haute-Garonne, France	*M. (Triloph.) Pyrenaicus* Lartet	= *Zygolophodon pyrenaicus*	Middle Miocene
11.	1859, 1879	Locality (?)	*Mastodon affinis* Jourdan (MS., labels in Lyons Museum); in Lortet and Chantre, 1879	= *Zygolophodon borsoni affinis*	Middle Miocene
12.	1867	Fulda, Germany	*Mastodon virgatidens* von Meyer	= *Turicius virgatidens*	Middle(?) Pliocene
13.	1883	Thorn, West Prussia	*Mastodon Zaddachi* Jentzsch	= *Zygolophodon borsoni zaddachi*	Upper Pliocene
14.	1922	Wahlheim and Esselborn, Germany	*Mastodon wahlheimensis* Klähn	= *Turicius wahlheimensis* [see Chap. VIII, p. 282, for description and figure]	Upper Pliocene
15.	1926	Sables de l'Orléanais, Chevilly (?), Cassegrain, Avaray, France	*Zygolophodon pyrenaicus aurelianensis* Osborn	= *Zygolophodon pyrenaicus aurelianensis*	Lower Miocene
16.	1926	Simorre, France	*Turicius turicensis simorrensis* Osborn	= *Turicius turicensis simorrensis*	Middle Miocene

Cuvier, 1806.—In Chapter V, "History of the Classification of the Mastodontoidea, Families and Subfamilies, 1705–1927," we have recited Cuvier's original description (1806) of "*Petit mastodonte*" (=*Turicius tapiroides*), a tooth from Montabusard, compared with one from Saxony; this specific description was confirmed by de Blainville in 1839–1864. Schinz (1824, p. 278) recognized Cuvier's five classic species and added the zygolophodont species '*Mastodon turicense*' from the Miocene lignites of Elgg, Canton Zurich, Switzerland. Subsequently the zygolophodont relationship of '*Mastodon*' *tapiroides* and of '*M.*' *turicensis* was recognized.

Hays, 1834, Aymard, 1847, Pomel, 1848.—The next step was that of Hays, clearly distinguishing the Middle to Upper Pliocene zygolophodont species as *Mastodon borsoni*. Then followed the descriptions of *Mastodon vialetii* and of *M. vellavus* by Aymard, of *Mastodon Buffonis* by Pomel, and of *Mastodon zaddachi* by Jentzsch—all of which species we now believe to be referable to *Zygolophodon borsoni*. See Hays' type figure and description on page 207 below.

Wagner, 1857.—In 1856 Gaudry and Lartet described *Mastodon pentelicus*. In 1857 Wagner cited (p. 140) the same animal as: "11. *Mastodon atticus* G. & L.," thus apparently attributing the species *pentelicus* to Gaudry and Lartet, but under another name. In Pl. vii, fig. 16, he referred to this species a maxillary fragment of another individual, on page 142 making reference to this specimen as follows: "In meinen früheren Erörterungen

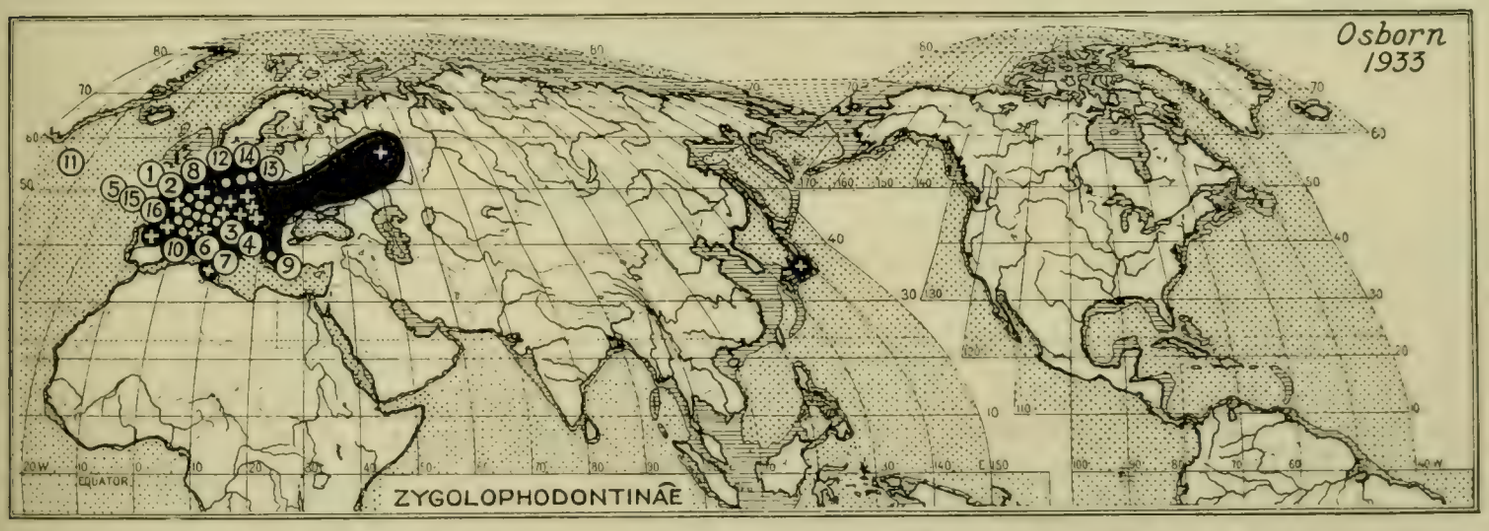


Fig 137. Geographic distribution (according to the numbers in the list opposite) of species of *Zygolophodon* and of *Turicius*. The white dots within the black areas represent the approximate localities where the types of these sixteen species were discovered. The white crosses represent referred specimens. The Japanese record is from the Tatsunokuchi, Lower Pliocene (Matsumoto, letter, 1924).

dieser Ueberreste habe ich es nicht gewagt, sie einer bestimmten Spezies von Mastodon zuzuweisen. Gaudry und Lartet haben sie jetzt als *Mastodon atticus* bezeichnet; ihre ausführliche Abhandlung, die noch nicht erschienen ist, wird jedenfalls die Gründe angeben, warum sie dieselbe von M. angustidens getrennt haben."

Osborn (1927) in the present Memoir points out that Wagner's maxillary fragment (Pl. vii, fig. 16) belongs to the genus *Turicius* and by courtesy adopts Wagner's specific name *atticus*.

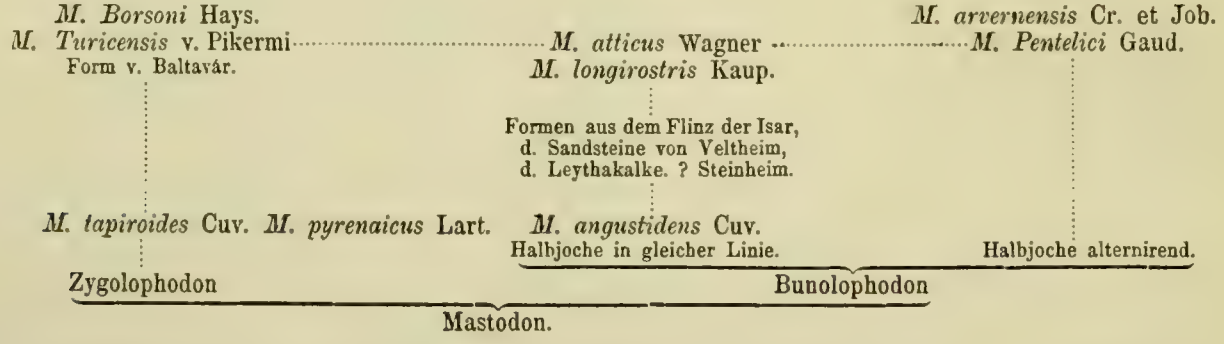
Gaudry, 1862.—Gaudry (1862, p. 153) pointed out that Cuvier established the name *tapiroides* on a single fractured milk molar ("molaire de lait"), a specimen which had been mentioned as early as 1783 by Defay; the third tooth cited by Defay was described by Cuvier as *M. tapiroides*.

Gaudry also pointed out, referring to Schinz, von Meyer, de Blainville, Lartet, and Kaup, that the teeth described throughout France as '*M.*' *tapiroides* chiefly belong to the '*M.*' *turicensis* Schinz. Gaudry then described (*op. cit.*, p. 155) and figured (Pl. XXIV, figs. 1 and 2) the jaws of a young specimen of '*M.*' *turicensis* from Pikermi, including three superior and inferior molars figured together in Pl. XXIV, fig. 1 (Fig. 165 of present Memoir); the superior premolars enlarged (Pl. XXIV, fig. 3) as compared with Cuvier's Lower Miocene type, the inferior premolars also enlarged (Pl. XXIV, fig. 4 –cf. Fig. 165 of present Memoir for Dp_4), and superior view of the jaw (Pl. XXIV, fig. 2 –Fig. 165 of present Memoir). These Lower Pliocene grinders of Pikermi age referred to '*M.*' *turicensis* appear to be *somewhat more progressive* than the Upper Miocene stage of '*M.*' *turicensis* of Schinz. The several characters cited by Gaudry are enumerated below in our specific description of '*M.*' *turicensis* in the present Memoir. See Pl. III, pp. 134–135, diagrams of *Turicius* molar evolution.

Lortet and Chantre, 1879.—The next great step was that of Lortet and Chantre (1879), when they brought together as Group II the following six species:

Mastodon tapiroides	*Mastodon borsoni*	*Mastodon vellavus*
" *turicensis*	" *buffonis*	" *vialetii*

This Group II corresponds in large part with Vacek's *Zygolophodon* published two years earlier. Finally, in 1909, practically the same zygolophodont group of species was adopted by Mayet.



Definition and phylogeny of *Zygolophodon* (subgenus *Bunolophodon*), in which the characters of the grinding teeth of *Zygolophodon* and of *Bunolophodon* (*Mastodon angustidens*, *M. arvernensis*) are contrasted. After Vacek, 1877, p. 45.

Vacek, 1877.—Meanwhile Michael Vacek, the Austrian palæontologist, in his Memoir "Über Österreichische Mastodonten," Vienna, July 1, 1877, gave a complete revision of the mastodonts of Europe from the primitive period of the contributions of Baldassari (1767), of Pallas (1777), of Buffon (1784), of Ildephons Kennedy (1785), to the contributions of Biedermann (1876). He especially mentions the masterly memoirs of Étienne Borson (Turin, 1820, 1823), the palæontologist to whom Hays dedicated his species '*Mastodon*' *borsoni* in 1834.

The most valuable parts of Vacek's contribution are his illuminating reviews of *Mastodon tapiroides* Cuv. (including *M. turicensis*, pp. 4–6), of *M. borsoni* Hays (pp. 6–11) in comparison with *M. angustidens* Cuv. (pp. 12–25), with *M. longirostris* Kaup (pp. 25–33), and with *M. arvernensis* Croizet and Jobert (pp. 33–39). In the case of each species valuable observations are given upon the known geographic distribution, as well as the resemblances and differences of the grinding teeth in relation to other species. Vacek sums up (pp. 39–45) the clear separation of his 'Group' *Zygolophodon* from his 'Group' *Bunolophodon*, as presented in his diagram herewith.

We may by courtesy take Vacek's group name as a valid definition of the genus *Zygolophodon* which he based on the species *Mastodon borsoni*, *M. turicensis*, and *M. tapiroides* (=*M. pyrenaicus*).

Vacek's diagnosis and diagram above embody a clear recognition of three distinct phyla corresponding with the three phyla of this Memoir, namely, the Zygolophodontinæ, the Longirostrinæ (=*Bunolophodon:* "Halbjoche in gleicher Linie"), and the Brevirostrinæ (=*Bunolophodon:* "Halbjoche alternirend"). Vacek concludes as follows (p. 45):

> Das Vorkommen von Uebergangstypen in einer Zeit, wo die beiden Formengruppen noch nicht so scharf geschieden waren, wie wir dies in den jüngsten Ablagerungen sehen, hat demnach nichts Auffallendes an sich, ja dasselbe muss sogar von vornherein erwartet werden, und die Trennung der Formen nach Massgabe ihrer phyllogenetischen [*sic*] Entwickelung oder die Trennung in Zygolophodonte und Bunolophodonte ist sonach eine natürliche. Wollten wir uns zum Schlusse nach den in diesem Aufsatze gegebenen Gesichtspunkten einen Ueberblick über die bisher bekannten europäischen Formen der Gattung Mastodon schaffen, so könnte man sich die Gruppirung derselben in folgender Art denken.

B. — MASTODONTES A MAMELONS DISPOSES EN CRÊTES TRANSVERSALES (TYPE LOPHODONTE)

Mastodon turicensis Schinz.

1825. ***Mastodon tapiroïdes***. Cuvier, *Ossements fossiles*, t. I, p. 267, pl. III, fig. 6. Cf. aussi Guettard, *Mémoires*, t. VI, 10e m., pl. VII, fig. 4.
1827. ***Mastodon turicensis***. Schinz, *Naturg. und Abbild. d. Säugethiere*, 1827, p. 243.
1842. ***Mastodon turicensis***. H. von Meyer, *Palæontologica zur Geschichte der Erde und ihrer Geschopfe*, Francfort.
1850. ***Mastodon tapiroïdes***. Blainville, *Ostéographie*, G. Eléphant.
1859. ***Mastodon Borsonii***. G. Gervais (p. part.), *Zoologie et Paléontologie françaises*, 2e éd., p. 68.
1878. ***Mastodon affinis***. Jourdan, *Archives du Muséum de Lyon*, t. II.
1878. ***Mastodon tapiroïdes***. Lortet et Chantre, Recherches sur les Mastodontes (*Archives du Muséum de Lyon*, t. II, p. 285, pl. VII et IX).
1887. ***Mastodon turicensis***. Depéret, Vertébrés miocènes de la vallée du Rhône (*Archives du Muséum de Lyon*, t. IV, p. 131).
1908. ***Mastodon turicensis***. L. Mayet, Mammifères miocènes des sables de l'Orléanais et des faluns de la Touraine (*Annales de l'Université de Lyon*, fasc. 24); — des sables de l'Orléanais, p. 194, pl. VIII, fig. 1 et 2; — des faluns du Blésois p. 298, pl. XI, fig. 4 et 5.

Type and referred species related to the *Mastodon tapiroides*, *M. turicensis*, *M. borsoni* groups. After Mayet, 1909, p. 45—all referable to the Zygolophodontinæ.

Mayet, 1908.—Whereas Vacek (1877) and Schlesinger (1917, 1922) adhere to the name '*Mastodon tapiroides*' throughout the Miocene, Mayet (1908, p. 196) abandons the above name in favor of '*Mastodon turicensis*' owing to the uncertainty as to Cuvier's lost type specimen. Mayet, on the other hand, sharply distinguishes the species *Mastodon pyrenaicus* Lartet from *M. tapiroides* (=*M. turicensis*) and points out that *M. pyrenaicus* occurs in the Lower Miocene, Burdigalian stage, as well as in the Middle Miocene horizon of the type specimen of Lartet. Compare also Mayet, 1909, p. 45, Section B, "Mastodontes à Mamelons Disposes en Crêtes Transversales (Type Lophodonte)" herewith.

Klähn, 1922, 1931.—Klähn, in describing (1922) the mastodonts of Baden and Rheinhessen, cites the species *Mastodon wahlheimensis*, which the present author regards as belonging to the Zygolophodontinæ. This is included, therefore, in the list of species on page 192 as *Turicius wahlheimensis;* it is not described, however, in the present chapter, but is briefly treated together with other of Klähn's species in Chapter VIII, Sec. 11, "Miocene and Pliocene Mastodonts of Baden and Rheinhessen," on pages 281–283.

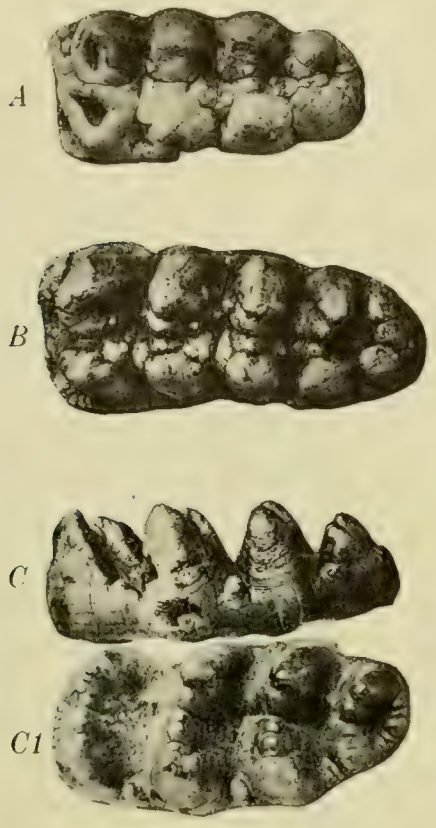
2. COLLATERAL RELATIONSHIP TO THE SUBFAMILY STEGODONTINÆ

Compare Vol. II, Chap. XV, Stegodontinæ (see Stegolophodon, Pl. iv, pp. 134–135)

Schlesinger, 1917.—Schlesinger (1917) in describing his type specimen of *Mastodon* (*Bunolophodon*) *longirostre* Kaup forma *sublatidens* n.f., discovered near Teschen (Schlesien), Austria, proposes the new subgeneric name *Stegolophodon* for '*Mastodon*' *latidens* Clift (see Schlesinger, p. 115, footnote):

> Ich schlage für *M. latidens* [Clift], das sich durch seine kurze Symphyse von dem Subgenus *Bunolophodon*, durch seinen Molarenbau von *Dibunodon* entfernt, den Untergattungsnamen *Stegolophodon* vor. Der Name bringt einerseits die nahen Beziehungen zum Genus *Stegodon*, anderseits die Loslösung der Untergattung von *Bunolophodon* und ihre Sonderstellung gegenüber *Dibunodon* zum Ausdruck.

Schlesinger's type specimen of '*Mastodon*' *sublatidens* from Teschen (Schlesien) certainly suggests the zygolophodont form of molar, but it more strongly resembles Clift's type of *M. latidens* from Burma, and stimulates



LOWER MIOCENE MIOMASTODON DEPERETI SP. NOV. (A), TRILOPHODON PONTILEVIENSIS (B), AND TURICIUS TAPIROIDES REF. (C, C1)

Fig. 138. A, B, From the Sables de l'Orléanais, Lower Miocene; C, from Pontlevoy, Lower Miocene. After Mayet, 1908, Pl. VII, figs. 3 and 5, Pl. XI, figs. 4 and 5, reduced to one-third natural size.

A, (*Op. cit.*, Pl. VII, fig. 3): "3.—*Mastodon angustidens.* Chevilly (sablière Cassegrain, au Glorieux, août 1877). Dernière molaire supérieure gauche. Paris, Muséum. Grandeur naturelle." [=*Miomastodon depereti* sp. nov.]

B, "5.—*Mastodon angustidens.* Chevilly. Dernière molaire supérieure [H. F. O. inférieure]. Paris, Muséum. Grandeur naturelle." [=*Trilophodon pontileviensis.*]

We observe that the *Trilophodon* grinders are much narrower than those of *Turicius.*

C, C1 (*Op. cit.*, Pl. XI, figs. 4 and 5): "4.—*Mastodon turicensis* [=*T. tapiroides* H. F. O.]. Pontlevoy. Dernière molaire inférieure. Paris, Muséum. Grandeur naturelle. 5.—*Id.* vue d'en haut." (See Fig. 139 for enlarged view of these teeth.)

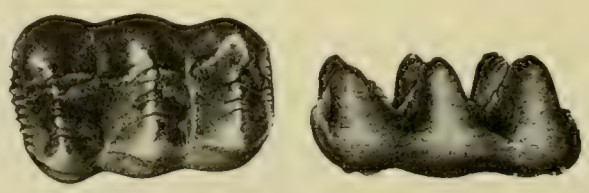
LOWER MIOCENE. TURICIUS (4, 5) AND TRILOPHODON (2)

Fig. 139. *Turicius turicensis* [=*tapiroides*] (upper 4, 5) compared with *Trilophodon pontileviensis* (lower 2), one-half natural size. After Mayet, 1908, Pl. XI, figs. 2, 4, and 5.

(Upper) Fig. 4.—"*Mastodon turicensis* [=*T. tapiroides*]. Pontlevoy. Dernière molaire inférieure. Paris, Muséum. Grandeur naturelle." Fig. 5.—"*Id.* vue d'en haut." (See also Fig. 138 C, C1.)

These molar teeth exhibit the profound difference between the zygolophodont molar (above), resembling that of a primitive Stegodont with uninterrupted, widely open valleys, and the bunolophodont molar (below), in which the valleys are closed by the *central conules.*

(Lower) Fig. 2.—"*Mastodon angustidens.* Falun de Pontlevoy. Dernière molaire supérieure. Communiquée par M. Jean de Bodard, Pontlevoy. Grandeur naturelle." [=*Trilophodon pontileviensis.*]



REFERRED TURICIUS TURICENSIS MOLAR

Fig. 140. A lower molar, l.M_2, from Murinsel, Croatia, referred by Vacek to *Mastodon* [=*Turicius*] *tapiroides*, but which appears to be closer to the stage *Turicius virgatidens.* After Vacek, 1877, Taf. VII, figs. 4, 4a, one-third natural size.

Observe that in *Trilophodon pontileviensis* central conules block the two anterior valleys; there are *four* conelets of unequal size in each loph. Observe in *Turicius* that all four of the valleys are open and free of *central conules;* each loph consists of *five* to *six* conelets, foreshadowing the ecto- and entoserrate lophs of the genotypic species *Turicius turicensis* (Fig. 162). In the Simorre stage, *Turicius simorrensis* (Fig. 141) displays serrate spurs from the ectoconelets.

The Lower Miocene *Trilophodon angustidens* of France (cf. *Trilophodon pontileviensis*, Chap. VIII, fig. 230) is paralleled by *T. cooperi* in India.

The Lower Miocene *Miomastodon depereti* sp. nov. of France is fully described in the Appendix of the present Volume I.

our comparison of the type molar of *Mastodon sublatidens* Schlesinger with the type molar of *Mastodon* [=*Stegolophodon*] *latidens* Clift. Schlesinger does not state whether he also applies his new subgeneric name *Stegolophodon* to his species *sublatidens*, but it is obvious that *M. sublatidens* and *M. latidens* belong to the same genus, i.e., *Stegolophodon*; consequently Osborn has referred *Mastodon sublatidens* to the subfamily Stegolophodontinæ[1] (Chap. XV), where it is treated in detail as *Stegolophodon sublatidens*. See Pl. IV, pp. 134–135.

Schlosser, 1903.—Long prior to Schlesinger's note, Schlosser suggested that primitive Asiatic species of *Stegodon* may have been derived from mastodonts related to the '*Mastodon*' *turicensis* of western Europe. A remote resemblance may be observed between specimens from the upper Middle Miocene of Simorre, France (Fig. 141), referred to *M. tapiroides* by Lartet (made the type of *Turicius turicensis simorrensis* by Osborn in 1926), and specimens from the Middle Pliocene of Perim Island, India, Lydekker's cotypes of *M. cautleyi* (see Fig. 142 A, B, Osborn's lectotypes of *Mastodon* [=*Stegolophodon*] *cautleyi*). See Pls. II–IV, pp. 134–135 (*Zygolophodon*, *Turicius*, and *Stegolophodon*).

Fig. 3 a.

Fig. 3.

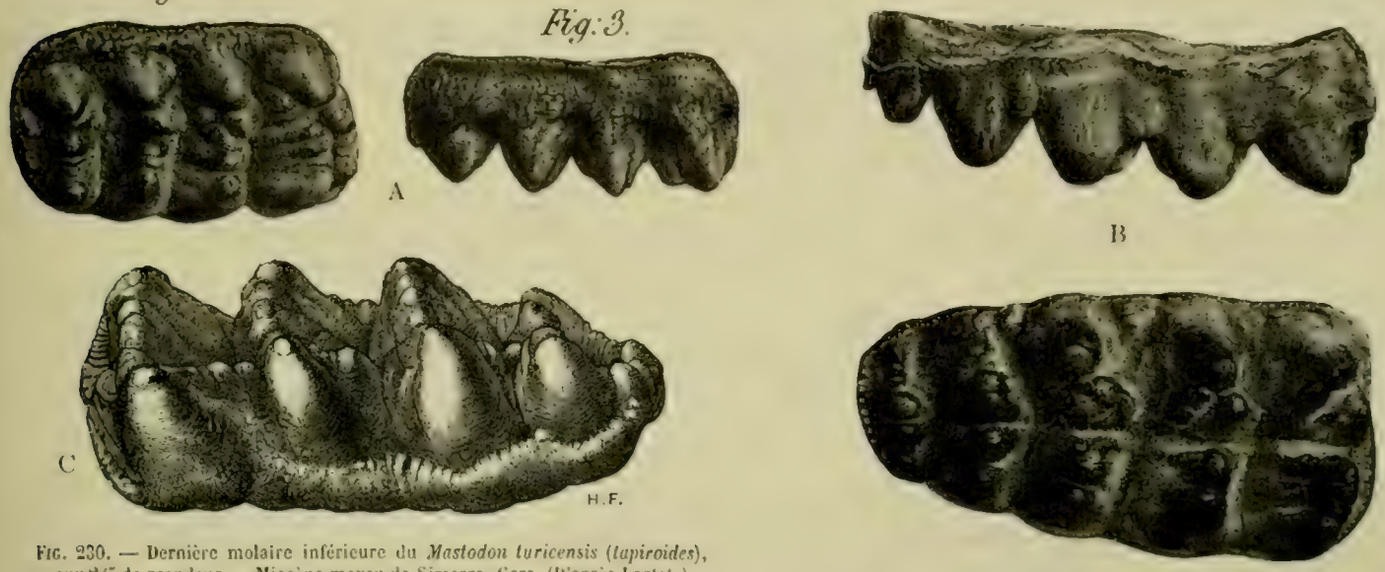


Fig. 230. — Dernière molaire inférieure du *Mastodon turicensis* (*tapiroides*), aux 2/5 de grandeur. — Miocène moyen de Simorre, Gers. (D'après Lartet.)

Turicius (C) and Stegolophodon (A, B) Form of Grinding Teeth

Fig. 141. (C) Type third right inferior molar, r.M_3, of *Turicius turicensis simorrensis*, erroneously determined by Lartet (1859, Pl. XV, fig. 3) as *Mastodon tapiroides*, two-fifths natural size. Upper Middle Miocene of Simorre. After Gaudry, 1878, p. 174, fig. 230. Reversed in drawing. See also pages 207 and 220.

Fig. 142. Cotypes of *Mastodon* [=*Stegolophodon*] *cautleyi* Lydekker, 1884. Lectotypes (Osborn), compare Volume II.

A, First superior molar of the left side, l.M^1, one-third natural size. After Falconer and Cautley, 1846 [1847, Pl. LX, figs. 3, 3a], as "*Mastodon latidens*." Length 4 inches, width 2.3 inches. Brit. Mus. M.2817. Cast Amer. Mus. 26965. Perim Island.

B, Third superior true molar of the left side, l.M^3, one-third natural size. After Falconer and Cautley, 1846 [1847, Pl. XXXI, figs. 6, 6a] as "*Mastodon latidens*." Length 8.5 inches, width 4.5 inches. Brit. Mus. M.2705. Cast Amer. Mus. 26966. Perim Island. See also Lydekker, 1886.1, p. 73, fig. 18.

A further striking resemblance to the *Stegodon* type is seen in the molar teeth referred by von Meyer to *M. turicensis* from the Upper Miocene lignites of Elgg and Käpfnach (Fig. 162). Finally the *M. virgatidens* type of von Meyer (Fig. 168) exhibits a progressive evolution somewhat closely parallel with progressive species of *Stegodon*.

It is not impossible that the forest-living *Zygolophodon* phylum of southern Europe may have given rise in Lower Miocene time to forest-living animals which spread eastward into the forests of southern Asia and developed into the Stegodont phylum. This whole phylogenetic problem is so important that it is treated more fully in Vol. II, Chap. XV, the Stegodontinæ, of the Stegodontoidea superfam. nov.

Osborn, 1935.—Osborn is inclined to favor Schlosser's suggestion of 1903 and Schlesinger's suggestion of 1917 that primitive European species (*Stegolophodon sublatidens*) may have given rise to primitive species of Stegodonts of Asia to which Schlesinger has given the new generic name *Stegolophodon*. See Pls. II–IV, pp. 134–135, also full treatment in Chapter XV (the Stegodontinæ).

[1]See Appendix of the present Volume I, pages 685 *et seq.*

3. ZYGOLOPHODON AND TURICIUS INDEPENDENT PHYLA (OSBORN, 1926) OF THE ZYGOLOPHODONTINÆ OSBORN, 1923. PLATES II AND III

As detailed above (pp. 192–197), beginning with Buffon in 1770 the Zygolophodontinæ (Osborn, 1923.601) were clearly separated (Osborn, 1926.706) from the Mastodontinæ chiefly by (1) multiplying conelets, (2) increasing sharpness of the ridge-crests, (3) open central valleys, and (4) absence of central conules and reduction of sulcus.

Schlesinger, 1917–1922.—In his detailed researches on the morphology, phylogeny, environment, and stratigraphy of the European mastodonts, Schlesinger gives repeated illustrations and summaries of the profound differences which exist between the species described in Europe as *Mastodon borsoni* and the species described as *Mastodon tapiroides*, the latter including the *M. turicensis* Schinz. We may therefore credit to Schlesinger (1922) the observation of clear and sharp distinctions not only between *M. americanus* and *M. borsoni*, sufficient to place them in different phyla, but of still more importance the *sharp distinctions* between specimens referred to *M. borsoni* and those referred to *M. tapiroides-M. turicensis*.

Osborn, 1927: Finally in studying the detailed structure and geologic stages of evolution of these Miocene and Pliocene Zygolophodonts, Osborn independently (1926.706, p. 3) concluded that they represent two genera, the included species of which may be given here as follows:

Zygolophodon Vacek, 1877	*Turicius* Osborn, 1926
Zygolophodon borsoni type, of Asti, Italy	*Turicius virgatidens* type, of Fulda, Germany
	Turicius atticus type, of Pikermi, Greece
	Turicius turicensis type, of Elgg, Switzerland
Zygolophodon pyrenaicus, Ile-en-Dodon, France	*Turicius turicensis simorrensis* type, of Simorre, France
	Turicius turicensis ref., of Pontlevoy, France
Zygolophodon pyrenaicus aurelianensis, Sables de l'Orléanais, France	*Turicius tapiroides* type, Calcaire de Montabusard, France

Whereas Vacek included *Mastodon turicensis* in his group *Zygolophodon*, Osborn points out that the type and referred specimens of *Turicius*, extending from the Lower Miocene of Pontlevoy to the Middle Pliocene of Germany, are clearly separable from the type of the true *Zygolophodon* and constitute a distinct ascending series of species with certain resemblances in the grinders to the species grouped under the genus *Serridentinus* Osborn. They thus constitute the types of a distinct genus *Turicius* typified by the typical *Mastodon turicensis* of Schinz but embracing a whole series of stages extending from the Lower Miocene to the Middle Pliocene.

4. RÉSUMÉ OF THE GENERIC AND SPECIFIC DISTINCTIONS

It appears that the *Zygolophodon* of Vacek divides into two generic phyla. Before we can clearly summarize the generic and specific characters of *Zygolophodon* and *Turicius* and the species included within them, it is necessary to concentrate our attention on the *type geologic locality and level* and the *characters of the type grinding teeth*. Previous failure in this respect has led to great confusion which exists even to the present time.

Geologically the *oldest* type is the *Turicius tapiroides* Cuv. from the Lower Miocene lacustrine Calcaire de Montabusard, France, but there is no certainty as to the precise characters of the type specimen. Geologically the *most recent* type is the *Zygolophodon borsoni* from the Middle to the Upper Pliocene of Asti, Italy; although there is some reason to believe that this species may have survived in eastern Europe into Lower Pleistocene time; it certainly disappeared in western Europe at the close of Pliocene time.

Type Localities.—The summary of the chief type localities, widely scattered through northern Italy Switzerland, Germany, and France, is as follows:

Type Localities	Original Name	Specific Reference in Present Memoir
Middle Pliocene, Villanova, Asti, Italy	Type of *Mastodon borsoni* Hays, 1834	= *Zygolophodon borsoni*
Middle Pliocene, Fulda, Frankfort, Germany	Type of *Mastodon virgatidens* von Meyer, 1867	= *Turicius virgatidens*
Lower Pliocene, Pikermi, Greece	Type of *Mastodon atticus* G. & L. (in Wagner, 1857)	= *Turicius atticus*
Upper Miocene, Elgg, Canton Zurich, Switzerland	Type of *Mastodon turicense* Schinz, 1824	= *Turicius turicensis*
Middle Miocene, Ile-en-Dodon (Haute-Garonne), France	Type of *Mastodon pyrenaicus* Lartet, 1859	= *Zygolophodon pyrenaicus*
Lower Miocene, Calcaire de Montabusard, France	Type of *Mastodon tapiroides* Cuvier-Desmarest, 1806–1822	= *Turicius tapiroides*

Specific Characters.—Having thus distinguished the *type geologic levels and localities*, let us clearly distinguish the characters of the type specimens in descending geologic order; these characters are based solely on the *type grinding teeth*, since our knowledge of the incisive tusks and of the characters of the jaws is very limited. Doubtless the tusks exhibit other distinct characters. See Pls. II and III, pp. 134–135.

Type M^3, *Mastodon borsoni* (see Figs. 154 and 111A, after Hays and Buffon) = *Zygolophodon*
Third superior molars tetralophodont (4–4½ crests), each loph composed of *four*[1] *distinct* and subequal conelets ('mamelons').

Type M_3, *Mastodon virgatidens* (see Fig. 168, after von Meyer) = *Turicius*
Intermediate molars trilophodont, posterior molars subtetralophodont, lophs acute with *five to nine connate* conelets ('Wulstkanten,' 'mamelons'); a serrate spur on superior internal conelets.

Type M^2, *Mastodon turicensis* (see Fig. 162, after Schinz) = *Turicius*
Second superior and inferior molars trilophodont, each loph with *five* to *six* more or less distinct conelets, no median sulcus; ridge-crests slightly arched or directly transverse; strong serrate spur on superior *internal* conelets.

Type M_3, *Mastodon pyrenaicus* (see Figs. 147, 148, after Lartet) = *Zygolophodon*
Third inferior molar tetralophodont plus, i.e., 4⅓ crested, each loph composed of *three* to *four*[1] more or less distinct conelets; no median sulcus; no serrate spur on external conelets; vestigial conules in anterior valleys.

Type r.M_3 of *Mastodon tapiroides* (see Fig. 160, after Cuvier, Fig. 161, after Mayet, also Pl. III A, pp. 134–135). = *Turicius*
Third inferior grinders tetralophodont, each loph composed of *five* to *six* conelets; no median longitudinal sulcus; vestiges of conules in the middle of the valleys; trefoil spur apparently on metalophid.

Generic Characters.—From the above principal characters of the *type* grinding teeth we observe that the universal *generic* character both of *Zygolophodon* and of *Turicius* is the *absence* or *reduction* of the *longitudinal* sulcus, fissure, or commissure, which Hays pointed out as the chief character distinguishing his type (Fig. 154) of *M. borsoni* from *M. americanus*. The absence or reduction of this sulcus distinguishes all the ascending species of *Zygolophodon* and of *Turicius*, from early Miocene to late Pliocene or early Pleistocene time, from all the ascending or ancestral stages of *Mastodon* in the corresponding period. We also observe that the fission of the cones into 'conelets' is rapidly progressive and distinct in *Zygolophodon* and in *Turicius*, whereas it is decidedly retarded in *Mastodon*. In many other features (compare Schlesinger, 1922) the progressive dental and skeletal evolution of *Zygolophodon* parallels that of *Mastodon*, as described in the previous chapter, namely, (1) the abbreviation of the jaws, (2) the suppression of the premolar dental succession, (3) the reduction of the lower incisive tusks, (4) the progressive abbreviation of the cranium. (5) From the fact that the *Zygolophodon* molars are relatively broader and shorter than those of *Mastodon*, it is probable that the cranium of *Zygolophodon* was more brachycephalic than that of *Mastodon*.

We may therefore give the following provisional generic distinctions of *Zygolophodon* and of *Turicius* from *Mastodon*, which will be amplified as we gain a more thorough knowledge of the skeleton. See also the full distinctions cited below (p. 211) from Schlesinger, 1922; also compare Mayet, 1908 (p. 204 of the present Memoir).

[1] *Four conelets* in types of *Zygolophodon pyrenaicus* and *Z. borsoni*; *four* to *six conelets* in progressive stages (Pl. II D–G).

MEDIAN VALLEYS OPEN, CENTRAL CONULES RUDIMENTARY OR ABSENT (5). SEE PLS. I–III, PP. 134–135

MASTODON	ZYGOLOPHODON	TURICIUS
Genotypic species: *Elephas* [=*Mastodon*] *americanus* Kerr.	Genotypic species: *Mastodon borsoni* Hays.	Genotypic species: *Mastodon turicensis* Schinz.
1. Longitudinal sulcus persistent between internal and external cones.	1. Longitudinal sulcus disappearing, vestigial.	1. Longitudinal sulcus disappearing, vestigial.
2. Main cones feebly subdividing at the summits into two conelets, progressive to four (Fig. 89, *Miomastodon*).	2. Main cones strongly subdividing into four to five subequal conelets, progressive to six (Fig. 151 and Pl. II).	2. Main cones subdividing into five to nine conelets, i.e., summits of lophs with quintuple, to sextuple, to octuple, to nonuple conelets (compare *Serridentinus serridens*, Figs. 388 and 389).
3. Retarded 'trefoil spurs' on superior internal cones and on inferior external cones.	3. 'Trefoil spurs' vestigial or absent.	3. Strong 'trefoil spurs' on superior internal and inferior external cones, hence 'serridentine.'
4. Grinders, Dp^2-M^3, relatively longer and broader, breadth-length index of M_3 not exceeding 57 (highest recorded index in Amer. Mus. specimens, Amer. Mus. 14345)—60.	4. Grinders relatively shorter and broader, index of M_3 = 43–45.	4. Grinders relatively longer, increasing in breadth.
5. Upper incisive tusks rounded, enamel band persisting into Miocene time.	5. Rudimentary conules or tubercles present in median valleys in early stages, i.e., *Zygolophodon pyrenaicus* ref.	5. Central conules vestigial in the median valleys in early stages (*T. tapiroides*).
6. Lower incisive tusks straight, cylindrical, variable.	6. Upper incisive tusks rounded, enamel band disappearing early, before Lower Miocene time.	6. Upper incisive tusks oval; enamel band sharp, persisting late, absent in *T. virgatidens*.
	7. Lower incisive tusks reducing early. Symphysis more abbreviated.	7. Lower incisive tusks suboval, vestigial in Pliocene stage. Symphysis less abbreviated.

GENERIC DISTINCTIONS INTO TWO GROUPS.—The Mastodontinæ so far as we know embrace one phylum of species, the Zygolophodontinæ, however, appear to embrace two phyla or groups (I and II) of species as follows:

I. In *Zygolophodon pyrenaicus*, type and referred, and in *Z. borsoni*, each loph of the grinding teeth subdivides into not more than *four*, to *four and a half*, to *five* to *six* conelets; the lophs are directly transverse not arched; trefoil spurs vestigial or absent. See Plate II.

II. In *Turicius turicensis* and *T. virgatidens*, each loph subdivides into from *five* to *nine* to *twenty-five* conelets; strong trefoil spurs arise on the superior internal conelets and on the inferior external conelets. See Plate III.

Consequently we appear to observe two ascending contemporaneous generic and specific phyla which do not intergrade. Geologically these phyla show two independent lines of ascent.

5. PROGRESSIVE CHARACTERS OF THE GRINDING TEETH

	I. *Zygolophodon*	II. *Turicius*
	Four to six persistent conelets on each grinding crest, 'trefoil spurs' vestigial or absent	Five to nine conelets on each grinding crest, progressive to twenty-five, 'trefoil spurs' more or less prominent
Upper Pliocene	*Zygolophodon borsoni* ref.	
Middle Pliocene	*Zygolophodon borsoni* type, Asti, Italy	*Turicius virgatidens* of Fulda, Germany
Lower Pliocene		*Turicius atticus* of Pikermi, Baltavár, etc.
Upper Miocene	Stage undescribed	*Turicius turicensis* of Elgg and Käpfnach, Switzerland
Middle Miocene	*Zygolophodon pyrenaicus*, Ile-en-Dodon, France	*Turicius turicensis* of Sansan and Simorre, France = *T. simorrensis*
Lower Miocene		*Turicius turicensis*, Faluns de Pontlevoy, France
Lower Miocene	*Zygolophodon pyrenaicus aurelianensis*, Sables de l'Orléanais, France	*Turicius* (?) *tapiroides*, Calcaire de Montabusard, France
	Parallel evolution with *Mastodon americanus* phylum	Parallel evolution with *Stegolophodon* and *Stegodon* phyla

Turicius. Undoubtedly constituting a phylum (Group II) distinct from above species of *Zygolophodon* (Group I) are the numerous grinding teeth referred by all recent European authors, especially Mayet, 1908, to '*Mastodon' turicensis*, first observed in the Lower Miocene Faluns de Pontlevoy and Sables de l'Orléanais, again

Fig. 143. Middle (=Étage Helvétien) and Upper (=Étage Tortonien) Miocene correlation. After Depéret (1905–1908) and Osborn (1910.346, p. 258, fig. 129). Horizons 1–69 arranged in ascending geologic order.

MIDDLE AND UPPER MIOCENE

Horizon of Sansan. FRANCE.—Calcaire de **1** *Sansan* (Gers), lacustrine. **2** *Jegun* (Gers). Faluns de **3** *Pontlevoy*, **4** *Sainte-Maure*, **5** *Manthelan*, in the basin of the Loire, marine. Mollasse de **6** *pont de l'Herbasse*, **7** *Bren*, **8** *Clérieux*, near Romans, marine. GERMANY.—Meeresmolasse (in Swabia) von **9** *Baltringen, Rammingen, Heggbach, Ursendorf, Hochgeland*, **10** *Hausen*, **11** *Niederstozingen*, **12** *Süssen*. Süsswasserkalk von **13** *Georgensgmünd*, **14** *Engelswies* (Bavaria). AUSTRIA-HUNGARY.—Braunkohle (in Styria) von **15** *Eibiswald, Wies*, **16** *Göriach, Gamlitz*, **17** *Voitsberg, Parschlug, Neufel, Leoben, Leiding, Feisternitz*. Marine sands of Grund at **17a** *Guntersdorf* (Lower Austria). Horizon of Simorre. FRANCE.—**2** *Bonnefond, St. Cristan* (Gers). **2a** *Villefranche d'Astarac*, calcaire de *Simorre* (Gers), lacustrine. Cinérites de **18** *Tournon*, in south central France. **19** *l'Isle-en-Dodon* (Gers). **20** *Saverdun* (Ariège). Mollasse de **21** *Mirabeau* (Vaucluse), marine. Marine deposits of **22** *Sorgues* (Vaucluse). Marine deposits of **23** *Romans* (Drôme). Sidérolithiques de **24** *La Grive-Saint-Alban* (in large part) (Isère), **25** *Mont Ceindre* (Rhône), **26** *Pretty near Tournus* (Saône-et-Loire), **27** *Gray* (Haute-Saône). GERMANY.—In Swabia, Bohnerz von **28** *Willmardingen, Jungnau* (in large part), Süsswasserkalk von *Steinheim, Ries, Urlau*, **29** *Nördlingen*, **30** *Althausen*. Bohnerz von **31** *Mösskirch*, **32** *Genkingen*, **33** *Heuberg*, **34** *Melchingen*. Gips von **35** *Hohenhöven* (Baden) (10 meters). AUSTRIA-HUNGARY.—In the intra-Alpine basin of Vienna, **36** *Dornbach, Vordersdorf, Loretto, Margarethen*, **37** *Fünfkirchen* (Hungary), calcaire de **38** *Bruck-a.-Leitha;* **39** *Breitenbrunn, Abstdorf-Franzensbad*, **40** *Mannersdorf*, **41** *Neudorf*. **42** *Trauenzinen* (Silesia). **43** *Krivadia* (Transylvania). **44** *Gyulu-Mendru* (Transylvania). **45** *Pesth* (Hungary). **46** *Ssoskut* (Hungary). RUSSIA.—**47** *Wosskressensk*. Horizon of Saint-Gaudens. FRANCE.—**48** *Valentine, Saint-Gaudens* (Haute-Garonne). **49** *Montréjau* (Haute-Garonne). SWITZERLAND.—Sands of **50** *Delsberg*, near Basel. **51** *Le Locle*, in the northwest. **52** *La Chaux-de Fonds*, in the northwest. **53** *Vermes*, near Basel. Mergelkalke von **54** *Œningen*, near Zürich, fresh water. Lignites of **55** *Elgg*, **56** *Käpfnach*, near Zürich. **57**, *Veltheim*, near Zürich, GERMANY.—In Bavaria: **11** *Günsburg; Reisensburg;* Sande von **58** *Häder, Dinkelscherben, Reichenau*, **59** *Diessen*, **60** *Dasing, Fraising, Tutzing, Stätzling, Reichertshofen*, **61** *Frontenhausen, Flinz of Munich*. **62** *Sankt Georgen* (Baden). AUSTRIA.—**36** *Heiligenstadt*, Tegel von *Hernals*, in Vienna basin. ITALY.—Lignites of **63** *Mt. Bamboli* (Tuscany). SPAIN.—**64** *San Isidro*, near Madrid. PORTUGAL.—**65** *Aveiras de Baixo*, near Oporto. RUSSIA.—**66** *Kriwoi-Rog* (Kherson). **67** *Nicolaieff*, at the mouth of the Dnieper. **68** *Sebastopol* (Crimea). **69** *Tiraspol*, near the mouth of the Dniester, Correlation of Depéret.

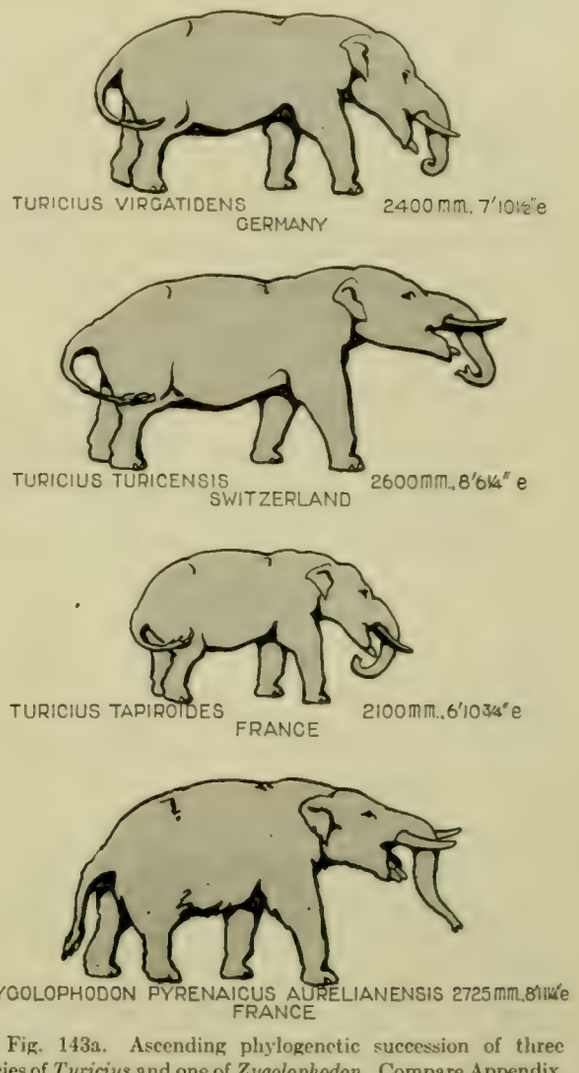


Fig. 143a. Ascending phylogenetic succession of three species of *Turicius* and one of *Zygolophodon*. Compare Appendix.

4. *Turicius virgatidens* of Fulda, Germany. Middle Pliocene.

3. *Turicius turicensis* of Elgg, Canton Zurich, Switzerland (see Fig. 143, **55**). Upper Miocene.

2. *Turicius tapiroides*, Calcaire de Montabusard, France. Lower Miocene. (See Fig. 146, **6**).

1. *Zygolophodon pyrenaicus aurelianensis*, Sables de l'Orléanais, France. Lower Miocene.

These outlines, restored to a one-hundredth scale, are chiefly after the grinding teeth and tusks, the skeleton and skull being relatively unknown or undescribed at the present time.

in the Middle Miocene of Sansan and of Simorre, again in the Upper Miocene of Elgg and of Käpfnach, and finally in the Lower Pliocene of Pikermi and of Baltavár. These animals show the strong upper internal and lower external serrated 'trefoil spur' ('Wulstkante' of von Meyer) also characteristic of *Serridentinus;* in fact, the grinding teeth show certain resemblances to the species included within the genus *Serridentinus*, but the lower incisive tusks of *Turicius* are *entirely* different from those of *Serridentinus*. Von Meyer observes that the

lower incisive tusks of *'M.' turicensis* are reduced and that the upper incisive tusks are oval in section and exhibit an enamel band in the specimens referred to *M. turicensis* from Käpfnach. In brief, there are many strong resemblances between the grinders of *Turicius turicensis* and the grinders of *Serridentinus;* consequently we are disposed to think that there may be an affinity of the genus *Turicius* to *Serridentinus* which may be demonstrable by fuller knowledge.

These animals certainly constitute a distinct genus, to which the name *Turicius* is applicable. Whereas Vacek defined *Zygolophodon* (1877) on three species, namely, *Mastodon borsoni*, *M. turicensis*, and *M. tapiroides* (=*M. pyrenaicus*), the genus *Zygolophodon* would now rest solely on the following species, *Mastodon borsoni* and *M. pyrenaicus.*

Osborn, 1935: In the Appendix of the present Volume are described two specimens of *Turicius turicensis* in the Munich Museum, which afford a fuller knowledge of the dentition, mandibular rami, and fore- and hind-limbs (see also Pl. III, pp. 134–135).

Anomalous Double Superior Incisors

Pontier and Anthony (Dec. 2, 1929) describe the right and left premaxillaries of a cranium referred to *'Tetrabelodon' turicensis* Schinz, of the following geologic age: "Villefranche d'Astarac, dans le Gers-Calcaire de Simorre-Helvétien-Miocène moyen." This interesting specimen, reconstructed in their figure 2 (*op. cit.*, p. 1006—

Fig. 144. Reconstruction by Pontier and Anthony, 1929, fig. 2, of the head of *Turicius turicensis* Schinz, of Villefranche d'Astarac, exhibiting the supplementary superior incisive tusks; inspired by Abel's restoration of *Trilophodon angustidens.*

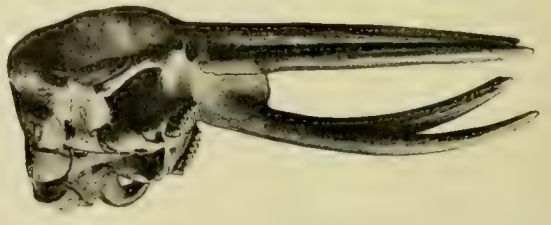


Fig. 145. Cranium of *Loxodonta africana*, from Fort Sibut, Equatorial Africa, exhibiting reduplication of the superior incisive tusks. After Anthony and Prouteaux, 1929, Pl. I, fig. 1.

reproduced herewith as Fig. 144), contains on both sides a supplementary superior incisor, which emerges immediately above the normal superior incisor (I^2). This was regarded by Pontier (1926, p. 162) as representing a vestige of, or reversion to, the first superior incisor (I^1) of the ancestral proboscideans. As to this question of homology, it is doubtful whether this anomalous tooth represents such a reversion, or a duplication of the crown of the normal incisor (I^2). This tooth has a diameter of 36 mm. as compared with 112 mm. in a normal tooth; it curves upwards rather than downwards; it is certainly an anomaly and not a specific character.

Comparison may be made with an analogous *Loxodonta africana* in the duplication of the superior incisors, as described by Anthony and Prouteaux (1929), of a wild elephant found in the Oubangui Chari region in French Equatorial Africa. In this instance the paired superior tusks, beautifully illustrated by the authors (Pl. I, figs. I–IV), emerge above the normal tusks and are directly horizontal in position, while the length nearly equals the normal (Fig. 145). According to the authors, such anomalies are not extremely rare among African elephants but they are decidedly exceptional; they are regarded by the natives as princes of the elephant tribe. We accept the interpretation of the authors (*op. cit.*, pp. 30, 31) that these anomalous teeth correspond with the second incisors (I^2) of *Mœritherium.*

6. CHARACTERS OF ZYGOLOPHODON AND ITS INCLUDED SPECIES

FAMILY: MASTODONTIDÆ Girard, 1852
SUBFAMILY: ZYGOLOPHODONTINÆ Osborn, 1923

GENUS: **ZYGOLOPHODON** Vacek, 1877

Original reference: Vacek, Abh. geol. Reichsanst., VII, Heft IV, p. 45. Wien.

Now resting on the genotypic species *Mastodon borsoni* and its apparently ancestral form *Mastodon pyrenaicus*. Compare *Mastodon* [=*Stegolophodon*] *latidens* of Burma, and *Mastodon* [=*Stegolophodon*] *sublatidens* Schlesinger of the Middle(?) Pliocene of Teschen (Schlesien), Austria. The genus *Stegolophodon* Schlesinger, 1917, proves to be distinct from the genus *Zygolophodon* Vacek. (See Plates II–IV, between pp. 134–135.)

GENERIC CHARACTERS OF ZYGOLOPHODON.—(1) Each loph divided into *four to six* distinct subequal conelets. (2) No trace of median longitudinal sulcus. (3) Conules or tubercles in median valleys disappearing in early stages. (4) Crests, i.e., lophs, directly transverse, not arched. (5) 'Trefoil spurs' vestigial or absent. (6) Fifth inferior crest, i.e., pentalophid, slowly progressive. (7) Superior incisive tusks rounded without enamel band (*Z. borsoni*). (8) Grinders permanently blunt, brachyodont (*Z. borsoni*), not becoming subhypsodont. (9) Progressive adaptations similar to those of *Mastodon americanus* rather than to those of *Turicius*. Compare generic characters listed by Osborn above (p. 200) and by Schlesinger below (pp. 210, 211, 217). (10) No inferior enamel band (*Z. pyrenaicus*).

The history of Vacek's generic name is related above in the present chapter. Vacek founded the genus *Zygolophodon* on three species, *Mastodon borsoni*, *M. turicensis*, *M. tapiroides* (=*M. pyrenaicus*). Osborn (1926.706) removed the species *M. turicensis* and made it the type of a new genus, *Turicius;* he also now removes the species *M. tapiroides*[1] Cuvier to the genus *Turicius*.

(1) The chief genotypic species is *Mastodon borsoni*[1] Hays, Middle Pliocene of Asti, Italy. This stage is very distinctly characterized by the *absence* of a longitudinal sulcus between the internal and external cones and by the *presence* of four distinct conelets in each loph, as clearly displayed in Hays' type figure reproduced in facsimile (Fig. 154) below; many teeth from different parts of Europe have been *referred* to *M. borsoni* by various authors which *lack the typical characters* of the *M. borsoni* grinders; certain of the grinders figured by Lartet exhibit four and a half to five conelets in one or more of the crests.

(2) Fortunately Lartet's type of *Mastodon pyrenaicus* (Figs. 147, 148) from the Middle Miocene of Ile-en-Dodon clearly exhibits *four distinct conelets* also tubercles in the first median valley. Mayet (1908, p. 197) also records it in the Lower Miocene, Sables de l'Orléanais, to which stage Osborn (1926.706) assigned the new subspecific name *Zygolophodon pyrenaicus aurelianensis*.

(3) UNCERTAINTY AS TO M. TAPIROIDES TYPE SPECIMEN.—The type molar of *Mastodon tapiroides* Cuvier from the Lower Miocene Calcaire de Montabusard, France, has been lost and there is a difference of opinion as to whether it is a true molar, or a deciduous premolar (Dp^4, Dp_4, von Meyer, Gaudry): Cuvier's figure reproduced in facsimile below (Fig. 160) certainly shows five main conelets in each transverse crest and intermediate tubercles or conules in the first and second valleys. The anterior portion of the crown is broken off. Mayet's new figure (Fig. 161) of the type shows five conelets and a 'trefoil spur,' which relate this specimen to *Turicius;* he regards it as ancestral to *Turicius* (see p. 205). Osborn (1935) determines this molar as an r.M_3 (see Pl. III A).

[1] *Mastodon tapiroides* was selected by Matthew as the type of *Zygolophodon* Vacek, 1877 (see Matthew, 1918.1, p. 200, footnote).

As von Meyer and Gaudry observed, the type appears small for a true molar. It is possible that when the type of *M. tapiroides* and other molar teeth from the Calcaire de Montabusard are studied, they may be found to exhibit characters other than those represented in Cuvier's type figure, on which our present description of this species rests. As independently observed by von Meyer and Gaudry, all the early French writers, including Lartet (1859), erred in referring similar specimens to Cuvier's species *M. tapiroides*. Von Meyer on the other hand states that there is no resemblance between the typical *M. turicensis* and the typical *M. tapiroides*; he considers (1867, p. 50) *M. turicensis* (*tapiroides*) as identical with *M. borsoni*.

(4) Mayet (1908, pp. 194–197) considers that: (1) Cuvier's type is not certainly derived from the Calcaire de Montabusard but more probably from the Sables de Chevilly or d'Ingré (see also Gervais, 1859, p. 68); (2) this small type may well be regarded as a milk tooth ("dent de lait").

Fig. 146. Chief Lower Miocene localities (=Étage Burdigalien, Sables de l'Orléanais Stage) and correlation of France, Switzerland, and Austria. After Depéret (1905–1908) and Osborn (1910.346, p. 250, fig. 126).

LOWER MIOCENE Burdigalian. FRANCE.—Sables de **1** *Neuville-aux-Bois* (Loiret), fluviatile, sables de *Rebréchien*, **2** *Marigny*, **3** *Fay-aux-Loges*, **4** *Beaugency*, **5** *Tavers*, **6** *Les Barres*, *Artenay*, marnes du *Blésois*, calcaire de *Montabuzard* (Loiret), lacustrine. Sables de **7** *Chilleurs*, *Chevilly* (Loiret), **8** *Neuvilly*, near Belgian frontier, fluviatile. Sables de **9** *Ruan*, north central France. Calcaires et marnes de **10** *Suèvres* (Loire-et-Cher). Faluns et calcaires de **11** *Pontlevoy*, faluns et sables de *Thenay*, in la Touraine. Sables de **12** *Chitenay* (Loire-et-Cher), fluviatile. Faluns de **13** *Manthelan*, in la Touraine, marine. **14** *Saint-Nazaire-en-Royans* (Drôme). Mollasse blanche de **15** *Angles* (Gard). LOWER-AUSTRIA.—Mollasse of **16** *Eggenburg*, marine. Marine deposits of **17** *Linz*. SWITZERLAND.—Muschelsandstein von **18** *Brüttelen*, **19** *Macconens*, *La Molière*, **20** *Bucheggberg*, western Switzerland, marine. PORTUGAL.—Mollasse of **21** *Horta de Tripas*, near Lisbon. GERMANY.—Spalte der Schieferbrüche von **22** *Solenhofen* (Bavaria). Correlation of Depéret.

Osborn, 1925: Cuvier's type is refigured by Mayet (1908, p. 195, fig. 66), as reproduced in figure 161 of the present Memoir; Mayet's figure (of natural size) exhibits five to six conelets in each loph, also a 'trefoil spur,' and certainly resembles the *M. turicensis* type, i.e., *Turicius*, more closely than the *M. pyrenaicus* type with its *four* conelets in each loph. Mayet concludes that, owing to the uncertainty as to Cuvier's type, the specific name *M. tapiroides* Cuv. cannot be conserved and should be replaced by the name *M. turicensis* (*op. cit.*, p. 196), "je crois préférable de suivre l'exemple de la majorité des auteurs en adoptant le nom de *M. turicensis* pour désigner l'espèce de l'Orléanais à dents tapiroïdes." Mayet continues (*op. cit.*, p. 197) that *M. pyrenaicus* also occurs in the Sables de l'Orléanais: "Le *M. pyrenaicus* que l'on trouve représenté dans les sables de l'Orléanais, se sépare

assez nettement du *M. turicensis* par ses molaires mi-partie tapiroïdes, mi-partie bunodontes pour que je n'hésite pas à maintenir distincte cette espèce créée par Lartet, d'après un certain nombre de pièces provenant de la région pyrénéenne (Saint-Frajou, Castelnau-Magnoac, Moncamp, etc.)." The species *M. turicensis*, i.e., *tapiroides*, extends throughout the entire Miocene period (Mayet, *op. cit.*, p. 197): "L'âge géologique du *M. turicensis* comprend tout l'ensemble du Miocène. On le voit apparaître, comme je viens de l'indiquer, dans le Burdigalien de l'Orléanais. On le retrouve pendant tout le Vindobonien et il se montre assez abondant dans la faune des Faluns de la Touraine."

Conclusions, Osborn, 1925: Our conclusion from Mayet's observations cited above is as follows: Both *Mastodon pyrenaicus* and *M. tapiroides* occur in the Lower Miocene Sables de l'Orléanais or Burdigalian; it follows that Group I (=*Zygolophodon*) and Group II (=*Turicius*) were separated from each other in Lower Miocene time.

Depéret and Mayet, 1925.—The recent views of Depéret and Mayet (letter, November 9, 1925), differing as regards *Turicius*, are as follows:

> J'ai dû différer de quelques jours ma réponse à votre lettre du 21 octobre dernier en raison de ce que je tenais à la soumettre à Monsieur Ch. Depéret. C'est donc son opinion bien plus encore que la mienne, que je vous exprime. La figure que j'ai donnée du *M. tapiroides* du calcaire de Montabusard, est la photographie agrandie de la figure type de Cuvier ramenée à la grandeur naturelle. Le *M. pyrenaicus* est à considérer comme un représentant d'un rameau différent, indépendant, du *M. turicensis*. Il ne semble pas possible de le rattacher au phylum *Turicius*, non plus qu'à tout autre. *M. tapiroides* et *M. turicensis* se présentent comme deux mutations d'un même rameau phylétique: l'une, plus ancienne, du Burdigalien; l'autre, plus récente, du Vindobonien. *M. Borsoni* et *M. americanus* sont bien certainement deux représentants d'un même groupe, sinon d'un même phylum. Toutefois M. Depéret se refuse absolument à admettre un passage quelconque ou une convergence de passage au *Stegodon*. *M. Borsoni* n'est connu nulle part en Europe avant le Pliocène. Vous connaissez certainement les deux beaux volumes, largement illustrés, de Schlesinger sur les Mastodontes d'Autriche et de Hongrie ainsi que le travail du même paléontologiste de Vienne paru en 1919: 'Die stratigraphische Bedeutung der europäischen Mastodonten,' *Mitteilungen der Geologischen Gesellschaft in Wien*, Band XI, 1918. Il indique bien que c'est seulement dans le 'Levantin' que *M. Borsoni* apparait dans l'Europe orientale tandis qu'en France, c'est dans le Pliocène inférieur (ancien).

The above opinions of Depéret and of Mayet concur in many points with those independently reached by Osborn (1925) in this Memoir, except that these distinguished colleagues do not place '*M.*' *pyrenaicus* in the ancestral phylum leading to '*M.*' *borsoni*, as Osborn at present is inclined to do. See Pl. II, pp. 134–135.

Rarity.—The extreme rarity of remains of specific stages of *Zygolophodon* is probably attributable to the strictly forest-living habits of these animals, similar to the forest-living habits of the Mastodontinæ, true mastodonts, which are rarely found fossil in the Tertiary of Europe or America but suddenly appear in great abundance in the Pleistocene forests of North America. Similarly *Zygolophodon borsoni* is relatively abundant in the Upper Pliocene deposits of all parts of Europe and of western Asia, but no traces of its ancestors have hitherto been described from the Lower Pliocene or Upper Miocene deposits of Europe. Consequently the succession of specific stages leaves many gaps, as shown in the following conspectus of the species placed in ascending geologic order.

4. Middle to Upper Pliocene. Zygolophodon borsoni Hays, 1834.

   Type r.M^3, ap. 155+ mm., tr. 87+ mm.; four conelets ('mamelons') subequal in size, six conelets in certain crests. Incisive tusks without enamel.

3. Upper Miocene. Stage undescribed.

2. Middle Miocene. Zygolophodon pyrenaicus Lartet, 1859.

   Type r.M_3, ap. 6½ inches, or 155 mm., tr. 2¾ inches, or 70 mm.; intermediate conules in first and second valleys, third valley without tubercles (Lartet). Pentalophid consisting of two small cones; external and internal conelets much larger than median conelets.

1. Lower Miocene. Referred Zygolophodon pyrenaicus Lartet (fide Mayet, 1908, p. 198), subspecies aurelianensis Osborn, 1926.

   Sables de l'Orléanais, Chevilly (?), Cassegrain, Avaray. Four conelets in each loph, intermediate tubercles in the valleys. This stage is now known as *Zygolophodon pyrenaicus aurelianensis*, since the abundant remains listed by Mayet (1908, p. 198) below are undoubtedly distinct specifically or subspecifically from the typical Middle Miocene *Zygolophodon pyrenaicus* of Lartet.

Referred Zygolophodon pyrenaicus of the Lower Miocene

Mayet (1908, p. 198) confirms the clear specific distinction of *M. pyrenaicus* and adds the very important fact that several specimens referable to *M. pyrenaicus* occur in the Lower Miocene, Burdigalian, fauna:

> J'ai retrouvé les principaux caractères indiqués par Lartet comme spécifiques du *M. pyrenaicus* sur quelques pièces découvertes dans les sables de la région d'Orléans: Un fragment de défense supérieure (Chevilly, sablière Cassegrain, collection Nouel) est de coupe sensiblement ovalaire, sans la moindre trace de bande longitudinale d'émail; . . . Une M_3 supérieure gauche (Avaray, musée d'Orléans) déterminée par M. Lartet lui-même, est à couronne très large, supportant quatre collines dont les deux premières ont leurs vallons partiellement interceptés par un tubercule accessoire; les deux collines postérieures, plus comprimées, presque tapiroïdes, sont séparées par des vallons libres; le talon postérieur est en forme de crête crénelée; . . . Une M_2 supérieure droite du musée d'Orléans, . . . provenant de Beaugency et déterminée par M. Lartet; . . . Une M_2 inférieure (musée d'Orléans, sans localité indiquée) est à trois collines, avec, en arrière, un assez fort talon tuberculé. . . . Le *M. pyrenaicus* avec sa dentition à caractère mixtes—buno-lophodonte—se rapproche à la fois du *M. angustidens* et du *M. turicensis*. Il marque peut-être le début de l'apparition des Mastodontes à dents tapiroïdes au commencement du Miocène et ne parait pas dépasser les horizons supérieurs du Miocène moyen.

Since Mayet observes both *M. pyrenaicus* ref. and *M. turicensis* ref. from the Sables de l'Orléanais, the separation of *Zygolophodon* (= *M. pyrenaicus* ref.) from *Turicius* (= *M. turicensis* ref.) in Lower Miocene, Burdigalian, time is completely established.

Zygolophodon pyrenaicus Lartet MS. (in Falconer, 1857), Lartet, 1859

Figures 147, 148, Pl. II B, pp. 134–135

Type: Middle Miocene, Ile-en-Dodon (Haute-Garonne), France.
Referred: Lower Miocene, Sables de l'Orléanais, France.

Lartet's type of *M. pyrenaicus* was examined by Falconer in 1857 and, owing to the presence of intermediate tubercles or conules in the anterior valley, was confused with his *Trilophodon*. Lartet's description, however (1859, p. 513), cited below, clearly distinguishes this excellent type molar from that of *Trilophodon angustidens* and compares it with that of *Mastodon tapiroides* and with that of *M. turicensis*, which Lartet considered as identical species; by others *M. pyrenaicus* has been identified with *M. turicensis*, but Depéret remarks (1887, p. 131) that it is clearly distinguished. The distinction between *M. turicensis* and *M. pyrenaicus* is well displayed in figure 148. Also see Plates II and III, pp. 134–135.

M. (*Triloph.*) *Pyrenaicus* Lartet MS. (in Falconer, 1857). Falconer, "On the Species of Mastodon and Elephant occurring in the fossil state in Great Britain." Quart. Journ. Geol. Soc. London, XIII, Pt. I, table opposite page 319.

M. [*Mastodon*] *pyrenaicus* Lartet, 1859. "Sur la dentition des proboscidiens fossiles (Dinotherium, Mastodontes et Éléphants) et sur la distribution géographique et stratigraphique de leurs débris en Europe," Bull. Soc. géol. France, (2), XVI, p. 513. Type.—A right third inferior molar, r.M_3. Horizon and Locality.—From near Ile-en-Dodon (Haute-Garonne), France. Middle Miocene. Type Figure.—Lartet, 1859, Pl. XV, fig. 4.

Type Description.—(Lartet in Falconer, 1857, opp. p. 319): "5. M. (Triloph.) Pyrenaicus (Lart. MSS.) . . . Upper Miocene. . . . France." (Lartet, 1859, p. 513): "Dernière molaire inférieure droite de *M. pyrenaicus* des environs de l'Ile-en-Dodon (Haute-Garonne). Cette espèce forme le passage du type à dents *tapiroides* au type à dents *mamelonnées*. La moitié antérieure de la dent a ses vallons en partie interceptés par des tubercules intermédiaires. Les vallons qui séparent les deux collines subtapiroïdes de la partie postérieure restent entièrement libres. Longueur de la couronne de cette dent qui provient d'un petit individu, 0,155; largeur entre les deuxième et troisième collines, 0,070."

Depéret, 1887, p. 131.—It was recognized as a valid species by Depéret (1887, p. 131) as follows: "Le *Mastodon Pyrenaicus*, Lart., se sépare assez nettement du *M. Turicensis*, au moins à l'état adulte, par la forme des mamelons de ses molaires, qui ont conservé sur la moitié antérieure de chaque dent la forme arrondie des Mastodontes omnivores, tels que le *M. angustidens*. M. le Prof. Gaudry (*Mammif. tertiaires*, p. 175) est disposé à admettre que les dents de *M. Pyrenaicus* seraient 'des molaires de *M. angustidens* qui tendent à devenir des dents de *M. Turicensis*.'"

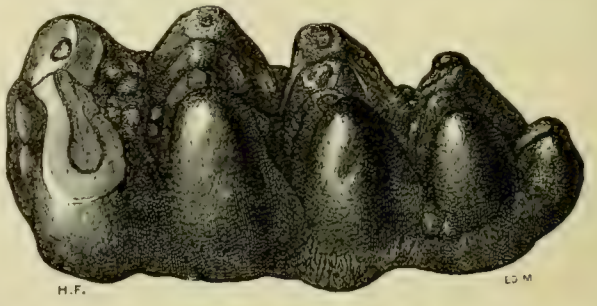


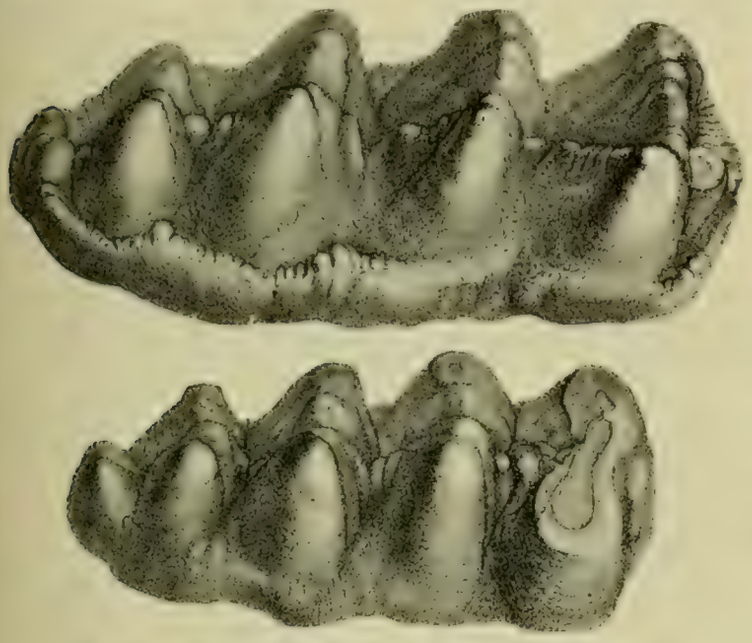
Fig. 229. — Dernière arrière-molaire inférieure de *Mastodon pyrenaicus*, à 1/2 grandeur. — Miocene moyen de l'Ile-en-Dodon. (D'après Lartet.)

Type of Zygolophodon pyrenaicus. Middle Miocene

Fig. 147. Type r.M_3 of *M.* (*Triloph.*) *pyrenaicus* (Lartet MS., *fide* Falconer, 1857, table opposite page 319); Lartet, 1859, Pl. XV, fig. 4. Middle Miocene. After Gaudry, 1878, p. 174, fig. 229. See figure 148, lower, of the present Memoir.

Osborn, 1922: The type of *M. pyrenaicus* apparently belongs to an animal of larger size than Cuvier's type of *M. tapiroides*, inasmuch as M_3 attains a length of 6½ inches. The stage of evolution is closely similar. In evolution, the three posterior lophs, with *four* 'mamelons' on each loph, agree quite closely with the

corresponding three posterior lophs in the Cuvier type of *M. tapiroides*, of Lower Miocene age. The type from Ile-en-Dodon (Haute-Garonne) was treated by Gaudry and Lartet as of *Middle Miocene* age. Depéret regards Ile-en-Dodon as of the same age as Simorre (cf. Osborn, 1910.346, p. 258—our Fig. 143) and a little more recent than Sansan, Middle Miocene. The original of the wood engraving after Gaudry (Fig. 147) is reproduced below (Fig. 148) directly after Lartet.



(Upper) Turicius turicensis simorrensis Osborn Type and (Lower) Zygolophodon pyrenaicus Lartet Type. Compare Figure 141.

Fig. 148. Lartet's type, r.M_3, of *Mastodon pyrenaicus* (Lartet MS., *fide* Falconer, 1857, table opposite page 319; Lartet, 1859, Pl. xv, fig. 4) compared with an r.M_3 (Pl. xv, fig. 3) erroneously determined by Lartet as *M. tapiroides*, now the type of *Turicius turicensis simorrensis* Osborn, 1926. After Lartet 1859.

Upper figure. (*Op. cit.*, p. 513): "Fig. 3. Dernière molaire inférieure droite du *M. tapiroides* des environs de Simorre (Gers). La hauteur des collines dépasse l'épaisseur de leur base. Les vallons qui les séparent sont en partie interceptés par une arête récurrente tuberculée dans le fond. La base interne de la couronne est entourée d'un collet saillant. Longueur de la couronne, 0,205; largeur entre les deuxième et troisième collines, 0,083."

This molar was chosen by Osborn, 1926.706, p. 4, fig. 2, as the type of the subspecies *Turicius turicensis simorrensis*. See pages 219 and 220.

Lower figure. (Lartet, 1859, p. 513): "Fig. 4. Dernière molaire inférieure droite de *M. pyrenaicus* des environs de l'Ile-en-Dodon (Haute Garonne). Cette espèce forme le passage du type à dents *tapiroides* au type à dents *mamelonnées*. La moitié antérieure de la dent a ses vallons en partie interceptés par des tubercules intermédiaires. Les vallons qui séparent les deux collines subtapiroïdes de la partie postérieure restent entièrement libres. Longueur de la couronne de cette dent qui provient d'un petit individu, 0,155; largeur entre les deuxième et troisième collines, 0,070."

Zygolophodon pyrenaicus aurelianensis Osborn, 1926

Lower Miocene, Sables de l'Orléanais, Chevilly (?), Cassegrain, Avaray, France. No type figure available to the author.

In 1926 Osborn (1926.706, p. 2) proposed the subspecific name *Zygolophodon pyrenaicus aurelianensis* for this Lower Miocene stage, to include the abundant remains listed by Mayet (1908, pp. 198, 199), as given below,[1] which in the present writer's opinion are undoubtedly specifically or subspecifically distinct from the Middle Miocene *Zygolophodon pyrenaicus* of Lartet.

Zygolophodon pyrenaicus aurelianensis Osborn, 1926. "Additional New Genera and Species of the Mastodontoid Proboscidea." Amer. Mus. Novitates, No. 238, p. 2. Cotypes.—(*Op. cit.*, p. 2); "Superior tusks and superior and inferior molars designated by Mayet as follows (Mayet, 1908, pp. 198, 199): 'Un fragment de défense supérieure (Chevilly, sablière Cassegrain, collection Nouel)est de coupe sensiblement ovalaire, sans la moindre trace de bande longitudinale d'émail; . . . Une M_3 supérieure gauche (Avaray, musée d'Orléans) déterminée par M. Lartet lui-même, est à couronne très large, supportant quatre collines dont les deux premières ont leurs vallons partiellement interceptés par un tubercule accessoire; les deux collines postérieures, plus comprimées, presque tapiroïdes, sont séparées par des vallons libres; le talon postérieur est en forme de crête crénelée; . . . Une M_2 supérieure droite du musée d'Orléans, . . . provenant de Beaugency et déterminée par M. Lartet; . . . Une M_2 inférieure (musée d'Orléans, sans localité indiquée) est à trois collines, avec, en arrière, un assez fort talon tuberculé.'" Horizon and Locality.—Sables de l'Orléanais, Chevilly (?), Cassegrain, Avaray, France. Lower Miocene.

Specific Characters.—(Osborn, 1926.706, p. 2): "Four conelets in each loph, intermediate tubercles in the valleys. The superior incisors are of oval section and lack all traces of the longitudinal enamel band."

Zygolophodon borsoni Hays, 1834

Figures 84, 111, 154, and Pl. ii, pp. 134–135

Type: Middle Pliocene, from near Villanova, Province of Asti, Piedmont, Italy.

Referred: Upper Pliocene of western Eurasia.

Syn.: *Mastodon vellavus* Aymard, 1847; *Mastodon Vialetii* Aymard, 1847; *Mastodon Buffonis* Pomel, 1848; *Mastodon affinis* Jourdan, 1859. According to Lortet and Chantre, also Depéret and Mayet, the above species are chiefly synonymous with *Mastodon borsoni* Hays. The obscure type description of *M. borsoni* by Hays was probably not accessible to these authors.

Hays' definition of this very important Middle to Upper Pliocene species, genotypic of the genus *Zygolophodon*, is consistent with his type figure (Fig. 154) also with Buffon's figure (1778) reproduced in figure 111 of the present Memoir. Étienne Borson, to whom this species was dedicated, described the same tooth as *Mastodon giganteum*, but called attention to its similarity to the tooth figured by Buffon. Hays observes (1834, p. 334): "we feel persuaded that it does not appertain to that species [*M. giganteum*], the denticles having no longitudinal commissure," thereby alluding to the absence of the median sulcus or longitudinal fissure which separates the internal and external cones in *Mastodon americanus*.

Borson, 1820–1823.—In 1820 ("Mémoire sur des Mâchoires et des Dents du Mastodonte dit Mammouth, Trouvées Fossiles en Piémont." Mem. Accad. Sci. Torino, XXIV) and again in 1823 ("Note sur des Dents du Grand Mastodonte Trouvées en Piémont et sur des Mâchoires et Dents Fossiles Prises dans la Mine de Houille de Cadibona Proche Savone." Mem. Accad. Sci. Torino, XXVII, p. 31) Professor Étienne Borson described and figured (Tav. ii) from near Villanova, Province of Asti, Piedmont, the portion of a jaw with grinders of a species "à dents étroites" to which Hays (Trans. Amer. Phil. Soc., 1834, p. 334) refers as follows:

[1] Mayet's description (1908, pp. 198, 199) of this Lower Miocene '*Mast.*' *pyrenaicus* is without figure. The specific distinctions are: (1) Oval superior incisors with no trace of enamel band; (2) third superior molar bunolophodont, four ridge-crests, crown relatively broad, posterior talon crest crenulate.

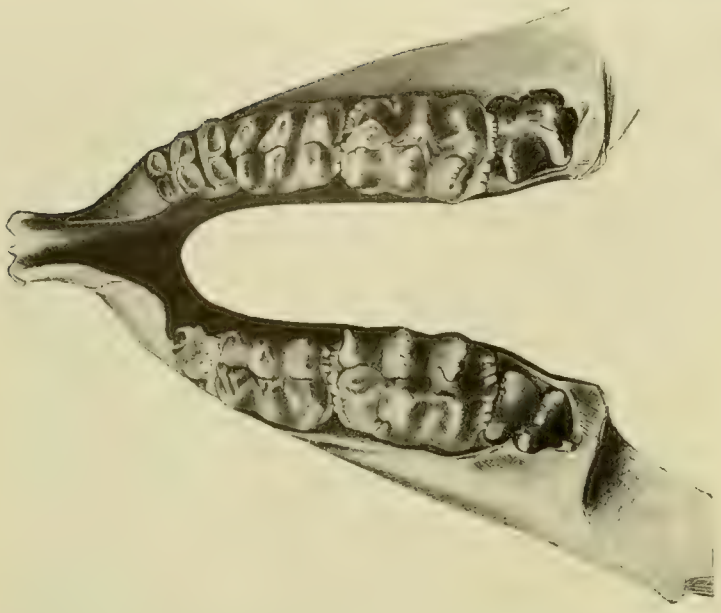


Fig. 149. Crown view of inferior dentition and jaw of *Mastodon americanus*, containing Dp_4, M_1, M_2, and M_3 anterior lophs. After Warren, 1852, Pl. v, one-sixth natural size. Reproduced for comparison with *Zygolophodon borsoni*.

Fig. 151. Second and third inferior grinders, l.M_2, M_3, of *Zygolophodon borsoni;* enlargement of same teeth as shown in figure 150. One-third natural size. Observe 4–5–6 conelets in proto-, meta-, and tritolophids respectively.

Fig. 152. Type of *Mastodon Zaddachi* Jentzsch, a second right inferior molar, r.M_2, length 112 mm., breadth 78 mm., index 69.6. From Thorn, west Prussia. Regarded as a subspecies or geographic variety of *Zygolophodon borsoni*, namely, *Zygolophodon borsoni zaddachi*. One-third natural size. After Jentzsch, 1883, Taf. v, fig. 6*a*.

Observe in *Mastodon* a median fissure, separating single inner and outer lobes. In *Zygolophodon* no median fissure; multiple conelets, sharp ridge-crests.

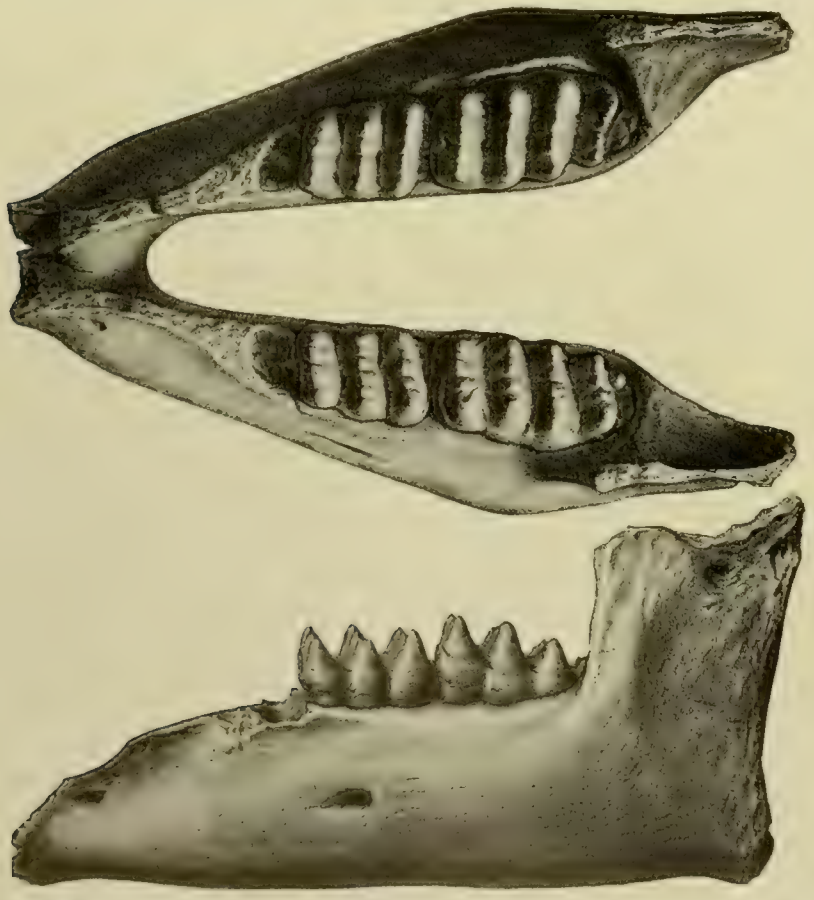


Fig. 150. Inferior dentition and jaw of *Zygolophodon borsoni* from Vialette (Haute-Loire), France. After Lortet and Chantre, 1879, Pl. XVI, figs. 1, 1a, one-sixth natural size. Reproduced for comparison with *Mastodon americanus*.

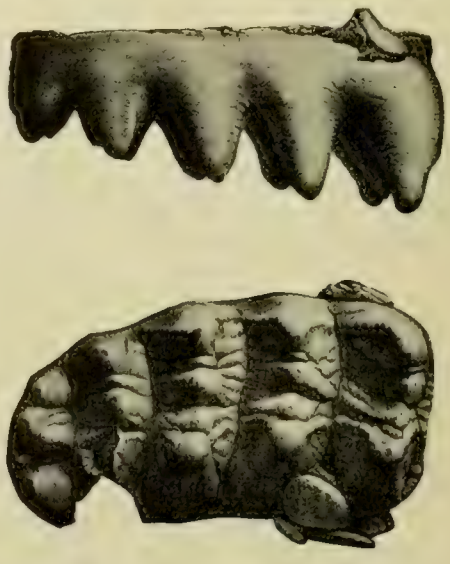


Fig. 153. Third superior molar, l.M^3, of *Zygolophodon borsoni* from "Le Petit-Rosey, vallon de Rochecardon, près Lyon," France. After Lortet and Chantre, 1879, Pl. XVI (bis), one-third natural size. Observe four main conelets and crenulated or plicated slopes of the lophs, suggesting those in *Mastodon americanus plicatus* Osborn (Fig. 120), as a parallel character.

Mastodon borsoni Hays, 1834.—"In the third volume of the Memorie della Reale Accademia delle Scienze di Torino, professor Borson has described a tooth, found at Villanova d'Astica, in Piedmont, and which he ascribes to the [*Mastodon*] *giganteum*. After a careful examination of the description and drawing, in the work referred to, and of a cast of the tooth, in the Cabinet of the Academy of Natural Sciences of this city, we feel persuaded that it does not appertain to that species, the denticules having no longitudinal commissure. It probably belongs to a new species, and we would suggest the propriety of dedicating it to professor Borson, under the name of *M. Borsoni*."

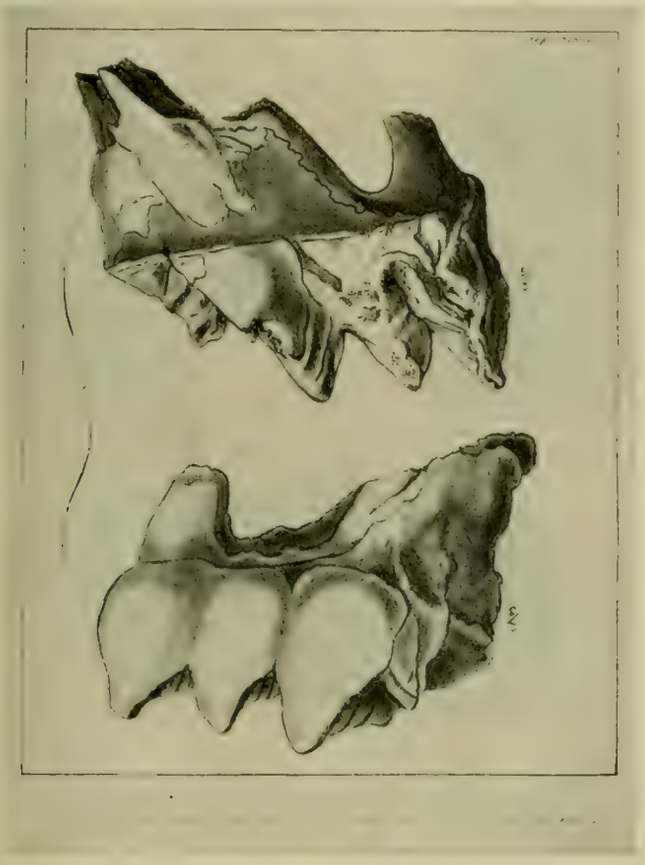


Fig. 154. Type r.M^3 of *Mastodon borsoni* Hays, 1834, one-third natural size. Originally figured two-thirds natural size by Borson (1823, Vol. XXVII, Tav. II) and referred by him to *M. giganteum*. From Villanova d'Astica, Piedmont, Italy. Cast No. 13352, Philadelphia Academy of Natural Sciences; cast Amer. Mus. 19238, gift of the Geological Institute of Turin, 1926. Reversed to show natural position of molar.

Lortet and Chantre (1879, p. 305) observe that *Mastodon borsoni* was described for the first time in 1823 [1820] by l'abbé Borson, (1820, Mem. Accad. Sci. de Turin, III, p. 160), and that Hays, who had in his possession a tooth [cast] found near Asti, Italy, applied to it the name of *borsoni* in honor of the abbé.

Osborn, 1925: This is the sixth reference to the occurrence of a member of the Zygolophodontinæ, namely, of *M. borsoni*, in Europe. As to the *type*, Professor Borson's designation (*op. cit.*, 1823, p. 33) is as follows: "La dent qui a quelque rapport avec la nôtre est celle que M. de Buffon a figurée dans le tome V du supplément à l'histoire naturelle, *pl.* 1, *pag.* 512, qu'il avait reçue de M. de Vergennes; avec cette différence cependant que dans la nôtre il n'y a que des vallées transversales; les pointes étant unies ensemble dans la largeur, ne laissent aucun lieu à des séparations et conséquemment aux vallées longitudinales." The above observation by Professor Borson is quite correct. Hays' type of *M. Borsoni* is obviously similar to the grinding tooth from "petite Tartarie" (Russia) described and figured by Buffon in 1778 and reproduced above in facsimile (Figs. 84, 111).

Osborn, 1926: A glance at the type of *M. borsoni* (Fig. 154), also at Buffon's figures of 1778, indicates that *Zygolophodon borsoni* belongs to a phylum distinct from *M. americanus*: (1) The molars are brachyodont, bluntly crested or lophoid; (2) each loph consists of four principal 'mamelons' or mamillæ compressed fore and aft; (3) as observed by Hays, there are no connecting crests, conules, or spurs between the lophs; thus when well worn, each of the anterior lophs shows four loops, as if this animal were a descendant of the *Z. pyrenaicus* molar type, with its four 'mamelons'; whereas the true *M. americanus* phylum always exhibits two loops from the wear of the two 'mamelons,' i.e., cones. From these distinctive characters, we infer that *Zygolophodon borsoni* was a short-limbed, forest-living, browsing type, with long upcurved tusks, distantly resembling *M. americanus*. Confirmation that it spread all over Europe and northwestern Asia, as originally observed by Buffon, is fully set forth by Pavlow (Chap. VI, pp. 133–135 above). Hays' description of this species was apparently unknown to Aymard, to Pomel, and to Jentzsch, who proposed the four following species:

'Mastodon' vellavus Aymard, 1847, p. 414.—"M. Aymard signale ensuite un Mastodonte surpassant de ⅓ le *Mastodon maximus* de l'Ohio, d'après un quatrième métatarsien, long de 0,255, large en haut de 0,110, en bas de 0,145, et ayant 0,095 dans son moindre diamètre. Il propose pour cette espèce le nom de *Mastodon vellavus*."

'Mastodon' vialetii Aymard, 1847, p. 415.—"Un troisième Mastodonte, plus petit de ⅓ que le précédent, caractérisé par un métatarsien long de 0,095, large de 0,060 en haut, et 0,070 en bas, au milieu de 0,049, et par des molaires larges de 0,074, à collines comme dans celui de l'Ohio; il devra se nommer *Mastodon Vialetii*."

'Mastodon' Buffonis Pomel, 1848, p. 258.—"Un mastodon à dents tapiroïdes accompagne presque toujours le *M. Cuvieri;* c'est le type des *M. tapiroides* Cuv.; mais il en est un autre qui se trouve au contraire en Auvergne et en Italie avec l'*angustidens*, dont les dents sont beaucoup plus épaisses et plus courtes, plus grosses en totalité, et qui nous paraît devoir constituer une espèce distincte. Les dents de Sibérie, attribuées au grand mastodonte, devraient lui être rapportées. On pourrait lui donner le nom de *M. Buffonis*."

'Mastodon' Zaddachi Jentzsch, 1883, p. 202.—"Der Zahn hat drei scharf ausgeprägte Joche und gehört somit in die Gruppe des M. tapiroides, M. Borsoni und M. Ohioticus, welche Vacek treffend als Untergattung Zygolophodon zusammengefasst hat." See figure 152.

Zygolophodon Vacek, 1877, pp. 6–11, Taf. VI.—Vacek gave a thorough review of the successive descriptions and characterizations of this species, including those of Hays, de Blainville, Lartet, Kaup, Gaudry, von Meyer, and Jourdan; throughout he uses the term '*Mastodon' tapiroides* as equivalent to '*M.' turicensis*.

He records as characters of *M. borsoni* specifically distinct from *Mastodon americanus* the following (after Lartet, 1859): (1) The greater proportional width of the grinders, the lesser height of the crests, the lesser prominence of the 'trefoil spurs' ('arêtes recurrentes'); (2) the clear distinctions of *M. borsoni* from '*Mastodon' tapiroides* (=*M. turicensis*), despite von Meyer's declaration (1867) that *M. borsoni* is inseparable from *M. turicensis;* (3) the absence in *M. borsoni* of 'trefoil spurs' ('arêtes recurrentes') which distinguish all species of *M. turicensis* (Lartet, 1859, Gastaldi, 1861); (4) the broad, short, and brachyodont crowns of *M. borsoni* as compared with the more prominent crests of *M. tapiroides;* (5) the *absence* of alveoli for lower incisors in the symphysis of the lower jaw, as observed by Jourdan and corroborated by Brandt (1860); (6) the exceptionally short symphysis of *M. borsoni* and the elevation of the coronoid process, as observed in the collections in the Munich and Lyons Museums, presenting a resemblance to the lower jaw of *Elephas.*

GEOGRAPHIC DISTRIBUTION[1]

Austria (Vacek, 1877, pp. 9–11).—Beginning with the type of *Mastodon borsoni* from the [Middle] Pliocene of Asti, Vacek traces the distribution of *M. borsoni* and of *M. tapiroides* (=*turicensis*) throughout Austria. He observes that the remains in the Upper Pliocene marine sands of Neudorf[1] agree in the closest detail with the type teeth of *M. borsoni* of Asti; that the Lower Pliocene locality of Baltavár lacks *M. borsoni* but contains *M. turicensis* (i.e., *tapiroides*) and exhibits the closest relationship to the fauna of Pikermi, although the specimen from Baltavár appears to approach the Middle Pliocene type of *M. borsoni* more closely than the '*M.' turicensis* described by Gaudry from Pikermi. From the illustrations in Vacek's Memoir, e.g., Taf. vi, figs. 3, 3a, the molar from the marine sands of Neudorf[1] does not correspond with Hays' definition and type of the species *M. borsoni;* also the posterior molar given in the same plate (Taf. vi, figs. 1, 1a) presents a prominent median longitudinal sulcus or fissure, which by Hays' definition is *absent* in the type of *M. borsoni.* This molar, M_3, from the sands of Theresiopel presents resemblances to the *Mastodon americanus f. praetypica* [=*Pliomastodon americanus praetypica* of the present Memoir]. See Plate i, pp. 134–135.

Hungary, Levantine, Schlesinger, 1922, p. 231.—Schlesinger observes (1922, p. 231) that '*Mastodon' borsoni* occurs in Rákos, a locality near Budapest, which yields also a large number of '*M.'arvernensis* and of '*M.' americanus f. praetypica* (*op. cit.*, p. 232): "Die Fundstelle ist der öfters erwähnte und nach seinen geologisch-stratigraphischen Verhältnissen auf S. 213 eingehend besprochene Schotter (Mastodonschotter). Sein levantines Alter steht vollkommen fest. . . . Obwohl *M. Borsoni* nur von wenigen stratigraphisch sicheren Fundstellen bekannt geworden ist, weisen diese doch so untrüglich immer wieder auf den einen Horizont, auf den wir schon zwei Mastodonarten beschränkt gesehen haben, das ich kein Bedenken trage, die Art als ein für das österreichisch-ungarische Gebiet rein levantines Tier zu erklären. . . . Allerdings ist die Bereicherung, die unsere Beweisführung für das ausschliesslich levantine Alter der Spezies in Österreich-Ungarn und den unmittelbar angrenzenden Ländern insbesondere vonseiten der rumänischen Funde erfahren hat, sehr erheblich. Wir können nunmehr mit grösserer Sicherheit diese stratigraphische Feststellung wiederholen und sehen *M. Borsoni* als ein in jeder Hinsicht sehr brauchbares Leitfossil des Levantins nur bestätigt."

Clear separation of 'Mastodon' borsoni from 'M.' americanus praetypica.—(Schlesinger, 1922, p. 227): "Wohl der entscheidendste und auch für den Stratigraphen wichtigste Schritt in der Erforschung der Zusammenhänge der jüngeren Zygodonten ist die Loslösung der beiden bisher stets in bunter Mischung als *M. Borsoni* beschriebenen Formen voneinander und die Klärung der phylogenetischen Stellung beider zueinander, zur Stammart und zum echten *M. americanus.* Es ist sehr erfreulich, dass uns von den beiden fraglichen Arten etliche Stücke aus sehr zuverlässigen Fundorten unseres Untersuchungsgebietes bekannt geworden sind. Ajnácskö (Kom. Gömör): Aus den Sanden und Schottern dieses Fundpunktes stammen die prachtvollen Reste, die ich auf S. 101—105, Taf. xvi, Fig. 1 u. 2, Taf. xvii, Fig. 1 und Taf. xviii, Fig. 5 dieser Arbeit bekanntgemacht habe. Es sind die sichersten Belege für die nahen Beziehungen dieses Tieres zum *M. americanus.*"

Fig. 155

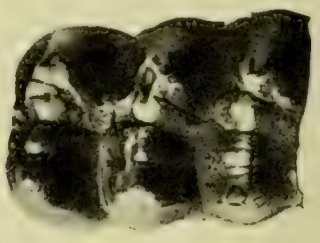


Fig. 157

Fig. 156

Fig. 155. Referred superior molar, l.M^1, of *Zygolophodon borsoni*, from the Pliocene marine sands of Neudorf[1], Austria. After Vacek, 1877, Taf. vi, figs. 3, 3a, one-third natural size. [=*Pliomastodon praetypica* ref. See Pl. i E, pp. 134–135.]

Fig. 156. Referred right inferior grinder, r.M_3, of *Zygolophodon borsoni* from Hidvég, Komitat Háromszék, Hungary. After Schlesinger, 1922, Taf. xvii, fig. 2, one-third natural size. Observe simple four conelets on each loph; four and a half lophs in all.

Fig. 157. Referred anterior half of third inferior molar, r.M_3, of *Zygolophodon borsoni* (erroneously attributed to ?North America), one-third natural size. After Schlesinger, 1922, Taf. xx, fig. 3. Observe four chief conelets on each crest.

(Osborn, 1934) Both Schlesinger and Vacek refer to *Zygolophodon* molars which prove to belong to *Pliomastodon* (see Pl. i, pp. 134–135).

[1]The Upper Pliocene marine sands of Neudorf, also Theresiopel, Nikolsdorf, and Baltavár (Vacek, 1877, Taf. vi, figs. 1–5a_1), yield a superb series of upper and lower grinding teeth which probably belong to *Pliomastodon*, although described and figured by Vacek as *M.* [=*Zygolophodon*] *borsoni.* See also specific revision in the phylogenetic appendix of the present Volume I.

DISTINCTIONS OF ZYGOLOPHODON BORSONI FROM TURICIUS

CHARACTERS OF 'M.' BORSONI.—Schlesinger (1922, pp. 79–81, also pp. 116–123) describes and figures numerous examples of the true *Zygolophodon borsoni* from Austria and Hungary, attributing this species to Upper Pliocene age. He distinguishes '*Mastodon*' *borsoni* from '*M.*' *tapiroides* (i.e., *Turicius turicensis*) by the following six characters (*op. cit.*, p. 79):

"Für *M. Borsoni* wurden nachfolgende Merkmale geltend gemacht: 1. Vollkommen geradegestreckte, etwas nach aussen gerichtete schmelzbandlose Stosszähne im Oberkiefer. 2. Vorhandensein einer mehr oder weniger funktionellen Mandibelschaufel mit zwei kleinen unteren Stosszähnen. 3. Im Zusammenhange damit Vorhandensein einer gegenüber *M. tapiroides* wenig reduzierten Symphyse. 4. Fehlen von Prämolaren [i.e., P 2-4]. 5. Jochformeln: $m\frac{1-3}{1-3}$: [Dp] $\frac{?,?}{?,?}$ [Dp 4] $\frac{3}{3}$: $M\frac{1-3}{1-3}$: [M 1]$\frac{3}{3}$, [M 2] $\frac{3(x),}{3(x),}$ [M 3] $\frac{4-4x}{4x-5}$. 6. Charaktere der echten Molaren:

a) Breite Kronen mit mehr oder weniger hohen Jochen, engeren Tälern als *M. tapiroides* und breiten Jochgraten; *b*) mediane Trennungslinien der Jochhälften in schwankender Ausbildung, bisweilen sehr kräftig und tiefeingeschnitten, bisweilen schwach; *c*) auffallend starke Entwicklung der Nebenhügel an den prätriten Halbjochen; *b*) schwankende Ausbildung der Sperrleisten an den prätriten Teilen." This valuable summary is as follows:

1) Superior incisive tusks straight, without enamel band.
2) Two small inferior incisive tusks, subfunctional.
3) Symphysis more reduced than in *Turicius*.
4–5) Permanent premolars lacking, intermediate molars (Dp 4-M 2) trilophodont. Third molars tetralophodont.
6) Molars as described by Hays and Vacek; feeble 'trefoil spurs.'

GRINDING TEETH EVOLUTION IN THE MASTODON, ZYGOLOPHODON, TURICIUS, AND STEGOLOPHODON PHYLA (PLS. I–IV, PP. 134–135)

PLATE I B–L *Miomastodon, Pliomastodon, Mastodon*	PLATE II B–G *Zygolophodon*	PLATE III A–J *Turicius*	PLATE IV A–I *Stegolophodon*
No median conules.	No median conules.	No median conules.	No median conules.
Conelets not exceeding 4.	Conelets 4 progressive to 6 on each ridge-crest.	Conelets 4–7–9–25.	Conelets bunoid, 4–6.
Persistent longitudinal sulcus.	Longitudinal sulcus irregular.	Longitudinal sulcus vestigial or absent.	Longitudinal sulcus disappearing.
Ridge-crests incomplete.	Ridge-crests separated by sulcus.	Ridge-crests sharply transverse and elevated.	Ridge-crests 4–6. Progressively arched, post-concave.
Trefoil spurs late in development (*Pliomastodon, Mastodon*).	No trefoil spurs.	Trefoil spurs present or absent.	No trefoil spurs.
Pleistocene *Mastodon acutidens* (Indiana) *Mastodon americanus* (Kansas)	Pliocene *Zygolophodon borsoni* (France) *Zygolophodon borsoni* (Siberia) *Zygolophodon borsoni* type (Piedmont, Italy)	Pliocene *Turicius virgatidens* (Fulda) *Turicius atticus* (Pikermi) *Turicius wahlheimensis* (Rheinhessen)	Pliocene *S. stegodontoides* type, India *S. latidens* type, Burma *S. cautleyi* (Perim Island) *S. sublatidens*, Austria
Plio-Pleistocene *Mastodon pavlowi* (Russia)			
Pliocene *Pliomastodon praetypica* (Hungary)			
Lower Miocene *Miomastodon depereti* (Chevilly) *Miomastodon americanus tapiroides* (see Fig. 98 D, D1 of Memoir), Hungary	Middle Miocene *Zygolophodon pyrenaicus* (France)	Miocene *Turicius turicensis* (Bavaria); D, ditto (Elgg, type); E, ditto (Elgg, ref.) *Turicius tapiroides*, France	Middle Miocene *S. cautleyi progressus*, India *S. nathotensis*, India Collateral ancestor of *Stegodon*, fully described in Chapter XV

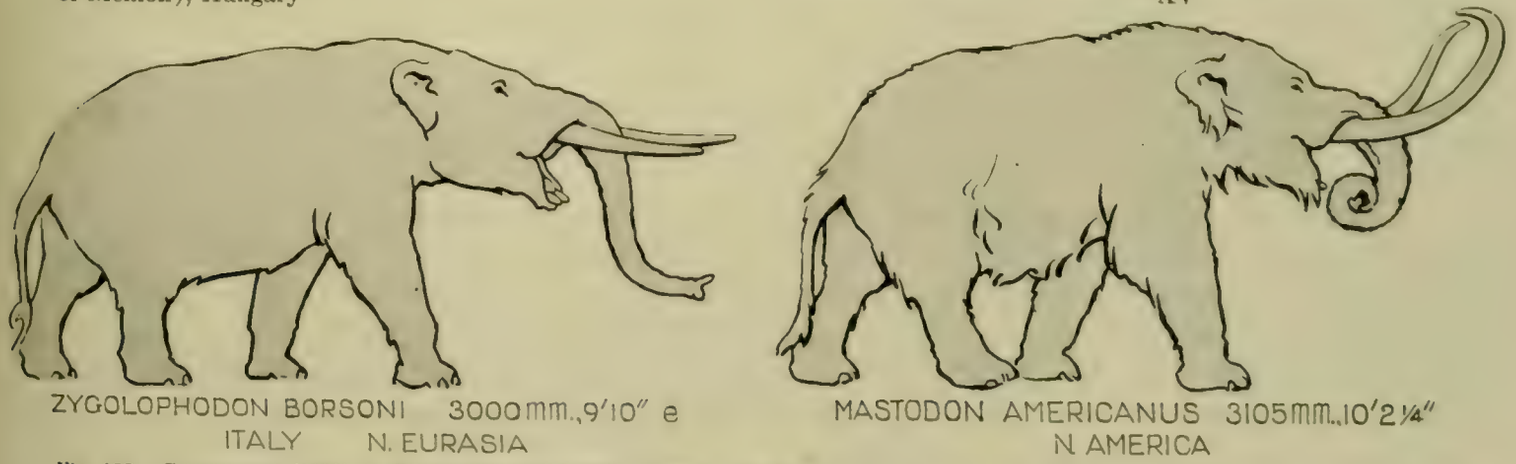


Fig. 158. COMPARISON (1932) OF ZYGOLOPHODON BORSONI (LEFT) AND OF MASTODON AMERICANUS (RIGHT), ONE SIXTY-SECOND NATURAL SIZE

(Left) Schlesinger (1922, pp. 79–81, 116–123) described the *Zygolophodon borsoni* of Austria-Hungary as of Upper Pliocene age. Cranial and body outlines largely conjectural, probably similar to *Mastodon americanus* but less woolly. Estimated height 3000 mm., 9 ft. 10 in.

(Right) Chiefly restored from the Warren Mastodon of Newburgh (see Fig. 124).

7. CHARACTERS OF TURICIUS AND ITS INCLUDED SPECIES AND MUTATIONS, AS COMPARED WITH ZYGOLOPHODON AND SERRIDENTINUS

FAMILY: MASTODONTIDÆ Girard, 1852

SUBFAMILY: ZYGOLOPHODONTINÆ Osborn, 1923; compare SERRIDENTINÆ Osborn, 1921, also STEGOLOPHODONTINÆ subfam. nov.

The species of animals described below were named *Mastodon tapiroides* by all early authors and more recently by Vacek and by Schlesinger. The same species are named *M. turicensis* by Schinz, von Meyer, Gaudry, Mayet, Schlosser, Cope, and other recent authors, except Schlesinger. Originally described from near Zurich, Switzerland, species of this genus were widely distributed in Europe and are even mentioned as occurring in Spain (Pavlow, 1894, p. 36); they are not recorded from Asia, although *Zygolophodon* is frequently recorded from northern Asia.

GENUS: **TURICIUS** Osborn, 1926

Original reference: Amer. Mus. Novitates, No. 238, p. 3 (Osborn, 1926.706).
Genotypic species: *Mastodon turicensis* Schinz, 1824.

GENERIC CHARACTERS.—(Osborn, 1926.706, p. 3): "Transverse crests, lophs, with five conelets progressing to eight or nine conelets.[1] Tubercles or conules retrogressive in the valleys between the crests. Median longitudinal sulcus vestigial in the early stages, completely disappearing in the progressive stages. Progressively strong 'trefoil spurs,' ['Wulstkanten,' 'arêtes'] on the superior internal cones and on the inferior external cones. Conelets increasingly connate at the summit, rising into sharp, subhypsodont transverse crests. Superior incisors oval in section, with sharply defined enamel band except in *Mastodon* [=*Turicius*] *virgatidens*. Inferior incisors without enamel, straight, suboval in section, undergoing progressive reduction. Symphysis of jaw progressively pointed and reduced in length, horizontal, unlike *Serridentinus*, in which the jaw remains elongate. Postero-inferior molars with four well-developed crests, the tetartolophid slowly progressive, the pentalophid rudimentary, but progressive in the higher stages. Gradual repression of the premolar dental succession, as in *Mastodon americanus* and in *Zygolophodon borsoni*."

The generic name *Turicius* and the specific name *turicensis* are derived from Turicum, the Latin name of Zurich, near which historic city the type specimen was discovered.

The grounds on which this genus is separated from *Zygolophodon* are recited above. *Turicius* in contrast with *Zygolophodon* is relatively well represented in all horizons from the Lower Miocene Faluns de Pontlevoy formation of France to the Lower Pliocene of Pikermi, Greece, and Baltavár, Hungary. Every museum in Europe contains a number of upper and lower grinding teeth, referable to various stages in the progressive evolution of *Turicius*, which are uniformly catalogued either as *Mastodon tapiroides* or as *M. turicensis*.

In a closer study of the *Turicius tapiroides* of the Lower Miocene we observe several primitive characters, and in ascending geologic levels we further observe a steady progression not only in size but in the stronger development of the characters which distinguish these species throughout from species of the true *Zygolophodon*. Vacek (1877) and Schlesinger distinguish these species clearly from *Mastodon* [=*Zygolophodon*] *borsoni*. Consequently there is no real resemblance between the final Pliocene stage in this generic phylum (*Turicius virgatidens*) and the final Pliocene stage of the *Zygolophodon* phylum (*Zygolophodon borsoni*).

[1]To twenty-five conelets in certain specimens (see Pl. III, pp. 134–135).

Whereas *Zygolophodon* is convergent or parallel with the true *Mastodon americanus* phylum, and in certain characters with the Stegodonts, the progressive molar stages of *Turicius* are similar in one character to those of *Serridentinus*, in other characters to *Stegodon* or to *Stegolophodon*. The upper tusks of *Turicius* are apparently distinguished by the persistence of the enamel band, while the lower tusks may readily be distinguished from those of *Serridentinus* by their suboval section and rodlike form, also by their gradual degeneration. All the specific stages referable to *Turicius*, however, require very careful reëxamination before these generic distinctions can be positively determined. Meanwhile the generic characters now known to us are probably as above (pp. 200, 212) and below (p. 217).

Conspectus and Measurements of the Species of Turicius in Ascending Geologic Order

See Plate III

The distinctive characters shown in the following series of geologic ascending species will doubtless prove of full specific value, but awaiting further examination, the trinomial nomenclature may be retained so as to connect these forms with the previous literature. In the succeeding pages of this chapter (VII) more detailed observations of von Meyer, of Gaudry, of Mayet, of Schlesinger, and of others are quoted or abstracted.

5. Middle (?) Pliocene. Turicius virgatidens von Meyer, 1867.
   'Gelben Lehme' bei Fulda, Germany. Much more progressive than *Turicius atticus;* lophs sharply pointed, broader and shorter superior incisive tusks, devoid of enamel band.
4. Lower Pliocene. Turicius atticus Wagner, 1857.
   Pikermi type (see Wagner, 1857, Tab. VII, fig. 16). Left P^4, ap. 30 mm., tr. 26 mm. Left M^1 trilophodont, ap. 54 mm., tr. 45 mm., proportionate in size to the Dp_4 of Gaudry's '*Mastodon' turicensis*.
3. Upper Miocene. Turicius turicensis Schinz, 1824. Type Stage.
   Elgg, Käpfnach, Schinz, 1824, von Meyer, 1867. Type l.M^2, ap. 94c mm., referred r.M_2, ap. 92 mm., six 'nebenhügeln' or conelets in each loph; median sulcus vestigial; strong 'trefoil spur' on second and third lophs. Superior incisors broadly oval to flattened, with sharply defined enamel band covering one-third of circumference. Small inferior incisors, without (?) enamel.
2. Upper Middle Miocene. Turicius turicensis simorrensis Osborn, 1926.
   Simorre (Gers), France (see Lartet, 1859—Figs. 148, 163 of present Memoir). M_3, ap. 205 mm., tr. 83 mm. Strong external trefoil crest; strong internal cingulum; tetartolophid well developed with four conelets; pentalophid rudimentary with two conelets. A premolar succession (Lartet).
1. Lower Miocene. Turicius tapiroides. Referred.
   Faluns de Pontlevoy (see figure by Mayet, 1908—Fig. 139 of present Memoir). M_3, ap. 147 mm., tr. 66 mm. Remnants of median sulcus; five to eight irregular conelets in each loph; no tubercles or conules in intermediate valleys.

The phylogeny, conelet and ridge-crest evolution of *Turicius*, from *T. tapiroides* to *T. virgatidens*, is clearly shown in Pl. III, pp. 134–135.

Comparative Measurements

(Notes, W. D. Matthew, September, 1920; References Modified by Osborn, 1925)

Molars referred to *Turicius turicensis* are represented in the Paris Museum by four specimens from Simorre (typical geologic level of *Trilophodon angustidens*), one from Sansan (Middle Miocene), and one from Pontlevoy (Lower Miocene), from which the extreme and average indices may be taken. The following measurements and indices were taken by Doctor Matthew, the specific references corresponding with labels in the Muséum d'Histoire Naturelle, Paris, 1920.

Lower, Middle, and Upper Miocene	M^1			M^2			M^3			M_3		
	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.
1872, Lartet, Simorre, '*Mastodon' turicensis* ref.										203	86	42
1784, Simorre, '*Mastodon' turicensis* ref.							143.5	80.2	56			
1838, Simorre, '*Mastodon' turicensis* ref.	80.7	51	63	113.8	67	59	130	73	56			
1862, Simorre, '*Mastodon' turicensis* ref.										155	66	43
1791, Sansan, '*Mastodon' turicensis* ref.	81	56.1	69									
1782, Miocene, '*Mastodon' turicensis* ref.							121	70	58			
1897, Pontlevoy, '*Mastodon' turicensis* ref.										147	66.7	45

Measurements of Type Molars

	M^1			M^2			M^3			M_3		
	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.
1867, Type of '*Mastodon' virgatidens* von Meyer, 'Gelben Lehme' bei Fulda				112	89	79	144e	91	63e			
[1857, Type of *Turicius atticus* Wagner, Pikermi]	(Dp^4, ap. 30 mm., tr. 26 mm., M^1, ap. 54 mm., tr. 45 mm.)											
1824, Type of *Turicius turicensis*, Schinz, Elgg				(M^2)94e (M_2)92								
1926, Type of *Turicius turicensis simorrensis* Osborn, Simorre										205	83	40
1824, Type of *Turicius tapiroides* Cuvier, Calcaire de Montabusard										85e		

The above tables of type and referred grinding teeth partly demonstrate a *progressive increase in size* of the grinders when viewed in *ascending* geologic order. This is doubtless accompanied by retrogressive abbreviation of the mandibular symphysis correlated with reduction of the inferior incisors.

Observations on Specimens from various Geologic Levels, Lower Miocene to Lower Pliocene, referred to 'Mastodon' turicensis or to 'Mastodon' tapiroides

According to von Meyer, de Blainville, and Suess, as cited by von Meyer (1867, pp. 48–61), the *M. turicensis* lophodont type of mastodont is widely distributed over Europe—France, Austria, Greece (Pikermi). Its abundance in the lignites, swamp formations, of Elgg, Käpfnach, and Eibiswald in Styria, points to its being an inhabitant of dense and partly swampy forests, although it occasionally occurs under more open conditions of life associated with *Trilophodon angustidens* and *Trilophodon* (*Choerolophodon*) *pentelicus*.

Osborn, 1922: Following the name *Mastodon turicense* given by Schinz (1824, p. 278), and the type figure of the Elgg tooth with description by Schinz (1833, pp. 58, 59), there came the full description (partly cited above) of this animal by von Meyer in 1867 (1867, pp. 48–61) with admirable figures of referred specimens (Taf. II and V, figs. 1–7), teeth associated with an Upper Miocene fauna in the lignites of Elgg and Käpfnach, believed to be of the same age as Saint Gaudens and somewhat more recent than that of Simorre which contains the type of *Trilophodon angustidens*.

All the intermediate molars of *Turicius* figured by Gaudry (1862, Pl. XXIV) and by von Meyer (1867, Pls. II and V, figs. 1–7) are *trilophodont* with a tendency to form elevated transverse crests composed of numerous confluent mamillæ or conelets grouped into outer and inner lobes.

The jaw of the Pikermi stage figured by Gaudry (*op. cit.*, Pl. XXIV, fig. 2—Fig. 165 of the present Memoir) shows a reduced and pointed symphysis with two vestigial incisors; it is totally unlike the symphysis of *Mastodon americanus*.

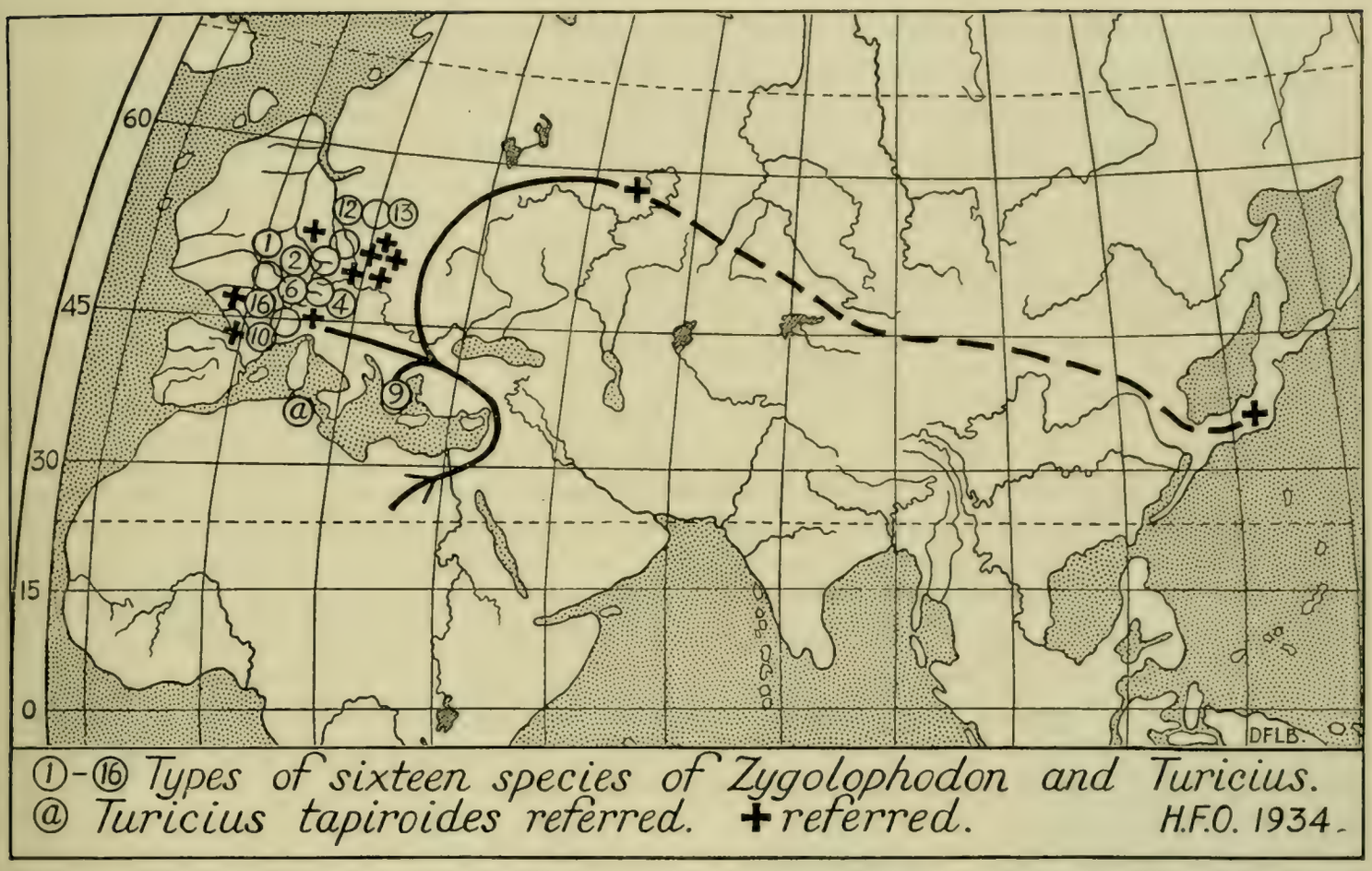


Fig. 159. Type localities (1–16) and theoretic migration lines of the forest- and swamp-loving *Zygolophodon* and *Turicius*. The crosses represent referred specimens, note especially *Zygolophodon borsoni* of Siberia and *Zygolophodon*(?) of Japan (*fide* Matsumoto); (*a*) represents *Turicius tapiroides* ref. of North Africa.

The third inferior molar of '*M.*' *turicensis* is described by von Meyer (1867, p. 50) as tetralophodont: . . . . "sondern um einen letzten unteren Backenzahn von M. Turicensis handelt. Es scheinen vier Querreihen überliefert, von der vierten freilich nur wenig. Die Querkämme sind erst schwach abgenutzt. Der Zahn erinnert auffallend an die typischen Zähne von Elgg." The lower incisors (*op. cit.*, Taf. v, fig. 6) are short, suboval in diameter, not dissimilar in form to the lower incisors of *Mastodon americanus*, totally dissimilar to those of *Trilophodon angustidens*.

In the Pikermi type of '*M.*' *turicensis* described by Gaudry (1862, p. 155), the lower incisors are still more reduced. The superior incisive tusks of the Elgg stage (von Meyer, 1867, Taf. II, figs. 4, 7, 8, and Taf. v, figs. 6, 7) exhibit a sharply defined enamel band covering about one-third the circumference of the tooth, which is broadly oval to flattened, not circular like that of *M. americanus*, also of relatively small size. (Von Meyer, pp. 54, 55): "Nach diesen von drei bis vier Individuen herrührenden Resten besass Mastodon Turicensis einen im Vergleich zu anderen Species auffallend kleinen Stosszahn. . . . Vergleicht man das, was ich für die obern Stosszähne von Elgg hervorgehoben habe, mit meinen Angaben über die oberen Stosszähne von Mastodon angustidens . . . so wird man finden, dass in letzterer Species die oberen Zähne, den unteren entsprechend, gegen die in M. Turicensis hauptsächlich durch überwiegende Grösse auffallen."

Typical Upper Miocene Turicius turicensis Schinz of Switzerland

Switzerland (Matthew, Notes, September, 1920. Turicius Osborn, 1926).—From the Upper Miocene lignites of Käpfnach (near Zurich) in the Zurich Museum are a jaw and lower tusks resembling *Turicius turicensis* rather than *Mastodon* [= *Trilophodon*] *angustidens* to which they are referred in the label. From the Upper Miocene of Käpfnach also are specimens which exhibit only a moderate elongation of the jaw, resembling that of *Serridentinus productus*, but with no decurvation of the symphysis.

Amidst the interesting fauna of Elgg, Canton Zurich, in lignites of Miocene age, also occur specimens referable to *Turicius turicensis*. Among the Sansan teeth in the Paris Museum is one marked "*M. turicensis*"; a somewhat worn and broken M_2 which may possibly be related to *Turicius tapiroides*; a small last upper molar, M^3, with only four crests, may also belong to this species.

Munich Museum (Matthew, Notes, September, 1920).—From the Upper Miocene of Flinz in the Munich Museum is a trilophodont specimen consisting of lower jaws, upper tusks and teeth, with parts of skeleton associated; this animal is larger than the typical *Trilophodon angustidens* and the teeth are relatively broader; the tusks are arranged as in *Serridentinus productus* ref. and *S. serridens* type from the Lower Pliocene of Texas, although relatively larger, more massive, the *symphysis heavier but not decurved;* there is no twist in the upper tusks which are larger than those in the American species *S. productus* and *S. serridens;* these tusks curve downwards, the enamel is external, the cross-section is oval; good fibulæ and a femur are associated, also larger part of the manus and pes. This is much too large and broad-toothed an animal to be properly referred to *Trilophodon angustidens*. Of the grinders, M^2-M_2 are trilophodont; M^3-M_3 tetralophodont, the tetartoloph being somewhat narrower; 'trefoil spurs' weak; grinding teeth relatively broad.

Osborn, 1925: The above observations of Matthew in the Zurich and Munich museums unquestionably relate these specimens to the genus *Turicius* Osborn and serve to distinguish species of this genus from species of the genus *Serridentinus* Osborn by the symphyseal characters of the lower jaw, namely: In the European *Turicius* the symphysis of the lower jaw is straight, not decurved; in the American *Serridentinus* the symphysis of the lower jaw is decurved and contains two large tusks of flattened oval section.

Turicius in Austria and Hungary

Von Meyer (1867, pp. 48–61) describes in great detail the widely distributed '*Mastodon*' *turicensis* of Austria, also the Upper Miocene lignitic forms from the typical localities of Elgg, of Winterthur, and of Käpfnach. He describes and figures two small inferior tusks, laterally compressed, 110 mm. in length, vertically oval, diameter ap. 27 mm., tr. 19 mm. (*op. cit.*, Taf. v, figs. 6 and 7); these teeth are apparently larger than those of the Lower Pliocene stage of '*M.*' *turicensis* described by Gaudry. He further describes referred superior incisive teeth (Taf. ii, figs. 2 and 3; Taf. v, figs. 1–5) as relatively large, vertically oval, diameter ap. 37 mm., tr. 28 mm., with fluted enamel band on the external surface (Taf. ii, figs. 7 and 8) from the typical locality of Elgg.

Throughout Schlesinger's invaluable Memoir of 1922 all the specimens referable to the genus *Turicius* are described by him as *Mastodon tapiroides*. He observes, however, that in six characteristics these animals appear to be clearly distinguishable from *M. angustidens* on the one hand and from *M. borsoni* on the other (*op. cit.*, pp. 77, 78). Consequently the characters by which Schlesinger distinguishes his *M. tapiroides* are cited below as distinctive of the genus *Turicius* Osborn.

[Generic and Specific Characters of Turicius. Osborn after Schlesinger, 1922, pp. 77, 78].—Den jüngeren Zygodonten gegenüber ist *M. tapiroides* als Spezies weitaus am sichersten unterschieden und durch folgende Merkmale gekennzeichnet: 1. Die oberen Inzisoren sind nach aufwärts gekrümmt, im Querschnitt oval und tragen ein wohlentwickeltes Schmelzband an der konvexen Seite. 2. Die unteren Inzisoren sind bis zu einem gewissen Grade denen des *M. angustidens* ähnlich, doch kleiner und bilden vereint keinen Spaten, sondern einen an der Spitze schief von oben vorne nach unten hinten abgestutzten Stechapparat zum Wühlen in der Erde. 3. Die Unterkieferschaufel war den Inzisoren entsprechend und nach Übergangsformen zu schliessen—spatelförmig ausgezogen, doch kürzer als die des *M. angustidens*. 4. Sowohl im Ober-, wie im Unterkiefer trug die Art je einen Prämolaren (*pm*$\frac{4}{4}$) (vgl. L.-V. 27, S. 149 und 156, Taf. xxi, Abb. 1 und 6). 5. An den drei Milch- und den drei echten Molaren kehren stets nachfolgende Jochformeln wieder: *m* [Dp] $\frac{1}{1} = \frac{3}{3}$: [Dp 2] $\frac{2}{1}$: [Dp 3] $\frac{3}{3}\frac{(3)}{(3)}$: [Dp 4] $\frac{3}{3}$: $M\frac{1}{1} = \frac{3}{3}$: [M 1] $\frac{3}{3}$: [M 2] $\frac{3^x}{3^x}$: [M 3] $\frac{3^x}{1} = \frac{1}{x}$. 6. Die Molaren sind in nachgenannten Punkten von denen der jüngeren Formen scharf unterschieden: *a*) Schmale Krone mit verhältnismässig niedrigen Jochen, weiten Tälern und engen Jochgraten (Jochkämmen): *b*) auffallend starke, tiefeingeschnittene mediane Trennungslinie der Jochhälften; *c*) schwache Entwicklung der Nebenhügel an den prätriten Jochteilen; *d*) stets bedeutende Betonung der prätriten Sperrleisten, die bisweilen ganz enorm entfaltet sein können.

Schlesinger concludes (*op. cit.*, p. 78) that the enamel band of the superior incisors and the presence of permanent as well as milk premolars clearly distinguish these animals from the more recent Zygolophodonts ("von den jüngeren Zygodonten").

SYSTEMATIC DESCRIPTION OF SPECIES OF TURICIUS. PLATE III

Turicius tapiroides Cuvier, 1806, 1821–1824; Desmarest, 1820–1822

Figures 77, 160, 161, also Pl. III A, B, C, pp. 134–135

Lower Miocene. Calcaire de Montabusard, France. Defay (1783) was the first to record '*M.*' *tapiroides* from this horizon (cf. Gaudry, 1862, p. 153).

This Lower Miocene stage is unfortunately imperfectly known because of the uncertainty regarding the characters of the type specimen. It is a very important stage owing to its extreme Lower Miocene age, since the Calcaire de Montabusard is regarded by Mayet as *underlying* the typical Sables de l'Orléanais; at the time Europe had a warm and dry climate and broadly depressed land areas. In the Sables de l'Orléanais occur grinding teeth referred to *Mastodon pyrenaicus* Lartet, with *four* conelets on each loph, which may correspond in character with Cuvier's lost type of *M. tapiroides* (see *Zygolophodon pyrenaicus aurelianensis*, p. 207.)

Petit mastodonte Cuvier, 1806. "Sur Différentes Dents du Genre des Mastodontes, mais d'espèces moindres que celles de l'Ohio, trouvées en plusieurs lieux des deux continens." Ann. Mus. d'Hist. Nat., VIII, p. 411. *Mastodonte tapiroïde* Cuvier, 1821. "Recherches sur les Ossemens Fossiles," Nouvelle Édition (2d edition), I, p. 268. *Mastodon tapiroides* (in Desmarest, "Mammalogie ou Description des Espèces de Mammifères," 1820–1822, p. 386); Cuvier, *op. cit.*, 1821–1824, V, Pt. 2, p. 527.

Type.—Considered by von Meyer (1867, p. 48) as a *premolar*, i.e., milk tooth, Dp 4 ('Milchbackenzahn'); also by Gaudry (1862, p. 153) as a "molaire de lait." Probably an imperfect third right inferior molar, r.M_3, of diminutive size.

Horizon and Locality.—Calcaire de Montabusard, France; Lower Miocene. (Osborn, 1910.346, p. 250, and our Fig. 146): "The Miocene is said [by Mayet (1908, p. 314)] to be introduced . . . in the [lacustrine] *calcaire de Montabuzard*, which records the return of the horses (*Anchitherium*). The overlying *sables de l'Orléanais* [containing the remains of *Trilophodon angustidens*] are fluviatile sands, laid down in successive stages which contain the entire rich Lower Miocene fauna, parallel with which are widely scattered deposits in France, Germany, Austria, Switzerland, and far to the southwest in Portugal near Lisbon. In this Lower Burdigalian stage the flora of Auvergne (*Myrica, Cinnamomum, Liquidambar*) indicates a warm and dry climate. . . . In the strata of the basin of Mayence the Oligocene flora, *Sabal, Sequoia, Laurus, Cinnamomum*, also persists. . . . The marine cetacean of the period is *Squalodon bariensis*."

Type Figure.—Cuvier, 1806.3, Pl. 68 (III), fig. 6. New type figure published by Mayet reproduced in figure 161 of the present Memoir.

Molar Described by Defay (1783), by Cuvier (1806)

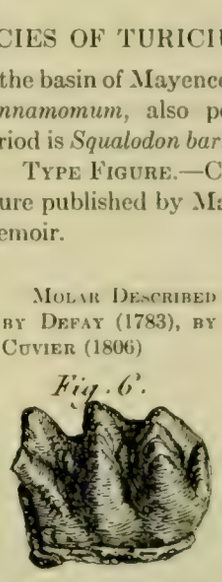


Fig. 160. Type r.M_3. *Petit mastodonte* Cuv., 1806, Pl. 68 (III), fig. 6, from the Calcaire de Montabusard. = *Mastodonte tapiroïde* Cuv., 1821, subsequently written *Mastodon tapiroides* (in Desmarest, 1820–1822, p. 386, in Cuvier, 1821–1824, V, Pt. 2, p. 527), = *Turicius tapiroides* in the present Memoir. This figure is one-half natural size.

Fig. 161. New type figure after Mayet, 1908, p. 195, fig. 66, natural size.

(Mayet, *op. cit.*, p. 195): "Cette dent est évidemment très petite et peut parfaitement être regardée comme une dent de lait. Mais la figure de Cuvier, pour imparfaite qu'elle soit, montre suffisamment les caractères essentiels du *M. tapiroïdes*, molaires à collines élevées, plutôt crénelées que divisées en mamelons, séparées par de larges vallées, sans mamelons intermédiaires, pour qu'il fût possible à la rigueur de conserver le nom spécifique de *M. tapiroïdes* donné par Cuvier."

Compare Pl. III, pp. 134–135, type of *Turicius tapiroides* (A) in comparison with *T. tapiroides* ref. (C).

Guettard, (fide Cuvier, 1821, I, p. 267, and 1834, II, p. 371).—The figures of Guettard, referred to by Cuvier, and the new type figure of Mayet (Fig. 161 of the present Memoir) relate this grinder more closely to *Turicius turicensis* than to *Zygolophodon pyrenaicus*.

Type Description.—(Cuvier, 1806.3, p. 411): "La dent de *Montabusard*, pl. III, fig. 6, correspond si bien à celle de Saxe pour sa largeur, que je ne doute pas que ce ne soit un germe de l'une des postérieures de la même espèce, cassé en avant."

(Cuvier, 1821, I, p. 268).—"Ainsi, indépendamment du grand *mastodonte de l'Ohio*, et du *mastodonte à dents étroites*, espèces aujourd'hui bien connues et parfaitement déterminées, nous trouvons des indices de quatre mastodontes, qui paroissent former d'autres espèces. Les deux qui viennent d'Amérique pourront s'appeler, lorsque leurs caractères seront entièrement confirmés, *mastodonte des cordilières* et *mastodonte humboldien*. Je donnerai au premier de ceux d'Europe le nom de *petit mastodonte*, et au second, dont les collines ne sont pas complétement divisées en mamelons, celui de *mastodonte tapiroïde*."

(Von Meyer, 1867, p. 48): "Cuvier's Mastodon tapiroides (Oss. foss., 4e. éd. II. p. 371. t. 28. f. 6) beruht einzig und allein auf einem noch dazu unvollständigen Milchbackenzahn, der mit noch zwei anderen Zähnen in dem tertiären Lacuster-Gebilde von Montabuzard bei Orleans in Frankreich gefunden wurde." Cuvier in the Fourth Edition of his "Ossemens Fossiles" (1834–1836), Vol. II, p. 371, states: "J'en donne la figure réduite à moitié, pl. 28, fig. 6. C'est la même qui a été gravée dans les Mémoires de Guettard, tome vi, x^e^ Mém., pl. vii, fig. 4." [An error, cf. Gaudry, 1862, p. 153, footnote 4.]

Osborn, 1935: It is very important to note that the type of *M. tapiroides* from the Calcaire de Montabusard, Lower Miocene, is possibly an imperfect *tetralophodont* third inferior molar with the anterior loph broken off; each loph in Cuvier's figure is composed of *four* to *six* transversely placed 'mamelons' (cf. Pl. III A) in contrast with the type of *M. americanus* which has two 'mamelons' in each transverse loph; thus a complete *M. tapiroides* tooth would be comparable to a complete tooth of the *M. pyrenaicus* Lartet type which has four 'mamelons' on lophs 2, 3, and 4.

Typical Lower Miocene Turicius tapiroides

Gaudry's (1862, pp. 157, 158) Mastodon tapiroides ('turicensis') of Pontlevoy.—(1) Superior milk molar (Dp^2) less enlarged than in the Pikermi stage, distinguished by an anterior conelet; (2) third superior milk molar (Dp^3) with conelet on each side of the median valley, not observed in the Pikermi form; (3) fourth superior milk molar (Dp^4) one-third smaller than the Pikermi form. (4) Third superior molar with feeble third crest (tritoloph), whereas the Pikermi molar exhibits an almost distinct third crest.

The above specific characters of the Lower Miocene, or Burdigalian, stage were regarded by Gaudry possibly as individual differences; with our present knowledge of the established fact, the Lower Miocene grinders of '*Mastodon*' *tapiroides* of Pontlevoy are much more primitive than those of the Lower Pliocene Pikermi stage (*Mastodon* [=*Turicius*] *atticus* Wagner) described by Wagner and by Gaudry.

Mayet, 1908.—Mayet (1908, p. 194) observes: "Mais comme le remarque P. Gervais (*Zool. et Pal. franc.*, 1859, p. 68) il ne paraît pas bien certain que ce morceau de dent vienne bien réellement du calcaire d'eau douce de Montabuzard; il provient beaucoup plus

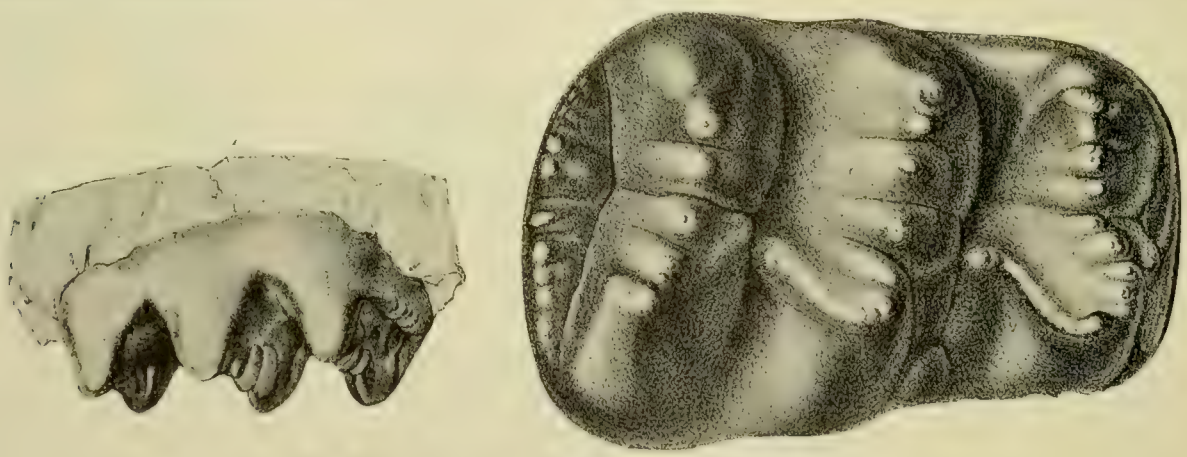


Fig. 162. Genotype and Homœotype of Turicius turicensis
See Pl. III D, E, pp. 134–135

(Left). Type l.M^2 of *Mastodon turicense* Schinz, 1824. After Schinz, 1833, Taf. I, fig. 1. Compare von Meyer, 1832.2, p. 72: "Mastodon Turicense. *Schinz. Schinz*, Mnspt." Subsequently written *Mastodon turicensis* (see von Meyer, 1839, p. 2). Original figure natural size; reproduced herewith one-half natural size. Zurich Collection. Elgg, Switzerland.

(Right). Upper Miocene of Elgg. Referred *Mastodon turicensis*, second inferior molar, r.M_2. After von Meyer, 1867, Taf. II, fig. 1. Sub-natural size (*op. cit.*, p. 52): "Die Krone ergiebt 0,104 Länge, in der hinteren oder dritten Querreihe 0,070 grösste Breite, in der vorderen nur 0,058." Winterthur Collection.

The Schinz type l.M^2 (left) of the species "*Mast. turicense*" becomes the genotype of the genus *Turicius* Osborn, 1926.

Observe in l.M^2 six and a half conelets in protoloph, six and a half conelets in metaloph, and nine conelets in tritoloph. Observe in r.M_2 eight to nine conelets in protolophid and strong postero-external trefoil spur, six conelets in metalophid and strong postero-external trefoil spur, six subequal conelets in tritolophid, no postero-external trefoil spur, strong posterior cingulum. Von Meyer's referred specimen (right) is certainly from the type locality of Elgg and represents the Upper Miocene Elgg stage of progression in the cones and conelets. Altogether there are twenty-two more or less distinct conelets in the three lophs of the second inferior molar. Compare these very distinct conelets with the closely connate, sharply pointed, and multiple conelets in the corresponding tooth, r.M_2, of the type of '*M.*' *virgatidens* (Fig. 168).

vraisemblablement des sables de Chevilly ou d'Ingré. D'un autre côté, plusieurs auteurs pensent que Cuvier aurait créé le type *M. tapiroïdes* sur des molaires de lait de *M. angustidens* [Footnote: 'Cf. Lortet et Chantre, Recherches sur les Mastodontes (*Archives du Muséum d'histoire naturelle de Lyon*, t. II, 1879, p. 308).']. Je n'ai pu retrouver soit à Paris, soit à Orléans, les pièces étudiées par Cuvier et toute la discussion ne peut porter que sur celle qu'il a figurée, réduite de moitié [Footnote: 'Ossements fossiles, t.I, pl. III, fig. 6.'] et que je reproduis ramenée à sa grandeur naturelle. Cette dent est évidemment très petite et peut parfaitement être regardée comme une dent de lait. Mais la figure de Cuvier, pour imparfaite qu'elle soit, montre suffisamment les caractères essentiels du *M. tapiroïdes*, molaires à collines élevées, plutôt crénelées que divisées en mamelons, séparées par de larges vallées, sans mamelons intermédiaires, pour qu'il fût possible à la rigueur de conserver le nom spécifique de *M. tapiroïdes* donné par Cuvier."

Turicius turicensis Schinz, 1824

Figure 162, also Pl. III D–G

Upper Miocene, Tortonian stage. Lignites of Elgg, Canton Zurich, Switzerland, also lignites of Käpfnach; age of Saint Gaudens.

The type description by Schinz of this Upper Miocene species is very meagre, but our knowledge of this stage is greatly amplified by the figures and characterizations of von Meyer. As the genotypic species of *Turicius* it is very important to observe closely the characters of the grinding teeth. The grinding teeth occur in relative abundance in the lignitic formations of Switzerland and of northern Italy, in some instances accompanied by the jaws, portions of the cranium, and the superior and inferior incisive tusks.

Mastodon turicense Schinz, 1824. "Naturgeschichte und Abbildungen der Säugethiere," 1824, p. 278. Type.—Second superior molar of the left side, l.M^2 (see Fig. 162, left).

Geologic Horizon and Locality.—Elgg, Canton Zurich, Switzerland; Upper Miocene, Tortonian stage. (See Osborn, 1910.346, p. 263): "This concluding phase of the . . . Miocene is, according to Depéret [Footnote: 'Depéret, L'évolution des Mammifères tertiaires (Miocène). *C. R. Acad. Sci. Paris*, Vol. CXLIII, Dec. 24, 1906, p. 1122.'], typified [in France] by the fauna of St. Gaudens [Fig. 143, **48**] on the head waters of the Garonne, which are paralleled (**48–69**) by the freshwater deposits of Œningen (**54**), near Zürich, the lignites of Elgg (**55**) and Käpffnach (**56**); in the same region, the mammals of Günsburg (**11**) and Stätzling (**60**) in Bavaria, the lignitic fauna of Monte Bamboli (**63**) in Tuscany, and the deposits of San Isidro (**64**), near Madrid."

Type Figure.—Schinz, 1833, Taf. I, fig. 1, also Pl. III D.

Type Description.—Schinz (1824, p. 278) gives a long detailed account of the various species of *Mastodon* of North and South America concluding with two lines on the *Mastodon* of Zurich, as follows: "Zürcherisches, Mast. turicense, Zähne dieser wahrscheinlich neuen Art wurden den Elgg im Canton Zürich in Braunkohlengruben gefunden."

Osborn, 1925: The following description and the accompanying figure (Fig. 162) reproduced from von Meyer (1867, Taf. II, fig. 1) are very important, because they constitute the first full definition and characterization of this species. Observe that each crest or loph, as in *M. americanus* (*ohioticus*), consists of two main lobes, which in *M. americanus* are simple or slightly bilobed at the summit, but in '*M.*' *turicensis* are subdivided into three or more 'Nebenhügeln,' 'mamelons,' or 'conelets,' six to nine in all. Von Meyer regards Cuvier's type of '*M.*' *tapiroides* as a milk tooth, a statement which requires verification by examination of the type. Observe also the spur ('Wulstkante') on the anterior and posterior slopes of the main internal lobe. Von Meyer rejects the direct relationship of '*M.*' *turicensis* either to *M. americanus* or to '*M.*' *tapiroides*.

(Von Meyer, 1867, p. 48): "III. Mastodon Turicensis Schinz. Mastodon Turicensis gehört zu den Trilophodonten. Er unterscheidet sich von dem derselben Gruppe angehörigen Mastodon angustidens hauptsächlich dadurch, dass die Krone seiner Backenzähne einfacher und dass die Stosszähne kleiner sind. Die Querreihen der Backenzähne stellen Querkämme, durch tief eingeschnittene Querthäler getrennt, dar; die Querthäler werden nicht durch Nebenhügel oder Hübel versperrt. Die Querkämme sind nicht einfach, . . . Die Querkämme zerfallen in eine deutlich zu unterscheidende äussere und in eine innere Hälfte, deren jede aus zwei, drei, selten aus mehr Hügeln oder Hübeln, die in der Richtung der Querreihe mehr oder weniger verschmolzen sind, zusammengesetzt ist. Der äussere und der innere Haupthügel eines Querkammes sind die stärksten, und von ihnen zieht vorn und hinten eine Wulstkante herunter. . . . Mastodon Turicensis gleicht noch am meisten M. Ohioticus, dessen Querreihen aber deutlicher in zwei Hälften getrennt erscheinen und deren Abnutzungsflächen mehr zum Rhombischen hinneigen. Durch die Aehnlichkeit der Zähne des Mastodon Turicensis mit dem Nordamerikanischen M. Ohioticus hat man sich verleiten lassen, das Vorkommen letzterer Species auch für Europa anzunehmen. Man glaubte ferner, dass die Zähne von M. Turicensis zu denen gehörten, welche Cuvier unter M. tapiroides begriff. Beides ist jedoch falsch. Cuvier's Mastodon tapiroides (Oss. foss., 4e. éd. II. p. 371. t. 28. f. 6) beruht einzig und allein auf einem noch dazu unvollständigen Milchbackenzahn, der mit noch zwei anderen Zähnen in dem tertiären Lacuster-Gebilde von Montabuzard bei Orleans in Frankreich gefunden wurde."

Turicius turicensis simorrensis Osborn, 1926

Figures 141, 148, 163

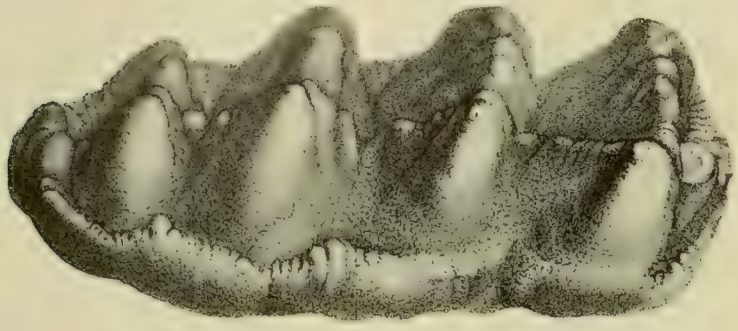
Upper Middle Miocene. From near Simorre (Gers), France.

This subspecific stage was based by Osborn (1926.706, p. 3) on a third right inferior molar, r.M_3, which Lartet in 1859, Pl. XV, fig. 3, erroneously determined as belonging to *Mastodon tapiroides*. The name *Turicius turicensis simorrensis* has been assigned to it, in reference to the locality in which the specimen was found. The distinctive characters of this molar tooth are readily seen by an examination of figure 148, where it is shown in comparison with the type right third inferior molar of *Mastodon* [=*Zygolophodon*] *pyrenaicus* Lartet (see also Fig. 163 below).

Turicius turicensis simorrensis Osborn, 1926. "Additional New Genera and Species of the Mastodontoid Proboscidea." Amer. Mus. Novitates, No. 238, p. 3. Type.—(*Op. cit.*, 1926.706, p. 3): "A third right inferior molar, r.M_3." Horizon and Locality.—Upper Middle Miocene. From near Simorre (Gers), France. Type Figure.—*Op. cit.*, 1926.706, p. 4, fig. 2.

Specific Characters.—(Osborn, 1926.706, p. 3): "Strong

external trefoil crest; strong internal cingulum; tetartolophid well developed with four conelets; pentalophid rudimentary with two conelets. A premolar succession (Lartet). Anteroposterior measurement 205 mm., transverse measurement 83 mm."



TYPE OF TURICIUS TURICENSIS SIMORRENSIS OF THE UPPER MIDDLE MIOCENE

Fig. 163. Type third inferior molar of the right side, r.M_3, of *Turicius turicensis simorrensis* Osborn, 1926, after Osborn, 1926.706, p. 4, fig 2, one-half natural size. From Simorre (Gers), France. Erroneously determined by Lartet as *Mastodon tapiroides*. Compare Lartet, 1859, Pl. XV, fig. 3 ("*M. tapiroides*"); also p. 513: "Dernière molaire inférieure droite du *M. tapiroides* des environs de Simorre (Gers). La hauteur des collines dépasse l'épaisseur de leur base. Les vallons qui les séparent sont en partie interceptés par une arête récurrente tuberculée dans le fond. La base interne de la couronne est entourée d'un collet saillant. Longueur de la couronne, 0,205; largeur entre les deuxième et troisième collines, 0,083."

It is noteworthy that this specimen from the upper Middle Miocene of Simorre contains five to six 'mamelons' on the three anterior lophs and is more progressively lophodont than the type of *Zygolophodon pyrenaicus* attributed to the Middle Miocene of Ile-en-Dodon. The wood engraving of this specimen after Gaudry is reproduced above in figure 141 of the present Memoir.

Turicius atticus Wagner, 1857

Figure 164, also Pl. III, 1

Typical Lower Pliocene of Pikermi, Greece.

Compare '*Mastodon*' *turicensis* described by Gaudry, 1862 (pp. 218, 220, and 221 of present Memoir).

This species rests upon the teeth described and figured by Wagner (1857) as *Mastodon atticus*, a specific name which has erroneously been regarded as a synonym of *Mastodon pentelicus* Gaudry, 1856. Restudy of Wagner's figure and description makes it apparent that this animal is entirely distinct from the bunomastodont *Trilophodon* (*Choerolophodon*) *pentelicus* and that it belongs to the zygolophodont phylum of *Turicius*. Consequently Osborn (1926) revives Wagner's specific name as appropriate for the [type] specimen of the Lower Pliocene stage of Greece, namely, *Turicius atticus*.

Mastodon atticus G. & L., Wagner, 1857. "Neue Beiträge zur Kenntniss der fossilen Säugthier-Ueberreste von Pikermi." Abh. bayer. Akad. Wiss., Band VIII, Cl. II, Abth. I, p. 140. [TYPE].—Left fourth superior premolar and first molar, l.P^4, M^1. HORIZON AND LOCALITY.—Lower Pliocene, Pikermi, Greece. [TYPE FIGURE].—Wagner, 1857, Tab. VII, fig. 16.

[TYPE] DESCRIPTION.—From Wagner's description of this specimen we may extract the following (Wagner, 1857, pp. 140–142): "Es ist nur ein kleines Bruchstück vom Vorderende eines linken *Oberkiefers* (Tab. 5 [Tab. VII] Fig. 16), was sich zugleich mit seinen beiden ersten Zähnen erhalten hat. Der *erste Backenzahn* hat eine ovale, nach vorn stark verschmälerte, etwas stumpf dreieckige Form, deren breitester Theil hinterwärts liegt; durch die Abreibung hat er noch nicht sonderlich gelitten. . . . Der *zweite Backenzahn* ist weit grösser als der erste, viel länger als breit, und nimmt nach hinten an Breite zu. Er ist durch zwei tiefe Querfurchen in drei Querhügel abgetheilt, die durch eine seichte Kerbe in der Mitte abermals gesondert sind. . . . In meinen früheren

TYPE OF TURICIUS ATTICUS

Fig. 164. Left fourth superior premolar and first molar, l.P^4, M^1, described by Wagner, 1857, pp. 140–142, as *Mastodon atticus* G. & L. Reproduced after Wagner's original figure, Tab. VII, fig. 16, reduced to two-thirds natural size. (Wagner, *op. cit.*, p. 158): "Vorderende vom linken Oberkiefer des *Mastodon atticus* mit den beiden ersten Backenzähnen."

Left P^4, measuring ap. 30 mm., tr. 26 mm., is functional as in *Serridentinus*. The three crested or trilophodont M^1, measuring ap. 54 mm., tr. 45 mm., is proportionate in size to the Dp_4 of Gaudry's '*Mastodon*' *turicensis* (Fig. 165).

Erörterungen dieser Ueberreste habe ich es nicht gewagt, sie einer bestimmten Spezies von Mastodon zuzuweisen. Gaudry und Lartet haben sie jetzt als *Mastodon atticus* bezeichnet; ihre ausführliche Abhandlung, die noch nicht erschienen ist, wird jedenfalls die Gründe angeben, warum sie dieselbe von M. angustidens getrennt haben."

'MASTODON' TURICENSIS OF PIKERMI.—The milk dentition probably belonging to the same species *Turicius atticus* was fully described by Gaudry, 1862, under the caption *Mastodon turicensis*. Gaudry's Pikermi specimen (1862, pp. 152–159, Pl. XXIV, figs. 1–4), fully described and figured as *Mastodon turicensis*, exhibits the following ten characters: (1) Ridge-crests: Dp $2\frac{2}{1}$ Dp $3\frac{3}{2}$ Dp $4\frac{3}{3}$; consequently the intermediate molars, Dp 4–M 2, are trilophodont; (2) the conelets are closely connate, resembling those in '*Mastodon*' *virgatidens* von Meyer rather more closely than the clearly separated conelets of the type of '*M.*' *turicensis* Schinz; (3) the superior tusks are flattened oval, a layer of enamel covering the superior and inferior surfaces; Lartet describes an enamel band on the convex surface of the '*M.*' *tapiroides* of Sansan; (4) the first superior milk tooth (?Dp^2) bears four irregular cones and the rudiment of a talon; (5) the second superior milk molar (Dp^3) bears two subacute crests with partly divided cones and two cones on the talon; (6) the third superior milk molar (Dp^4) is composed of three distinct crests surmounted with numerous conelets, with a trace of a trefoil spur ("une trace d'arête") on the inner side.

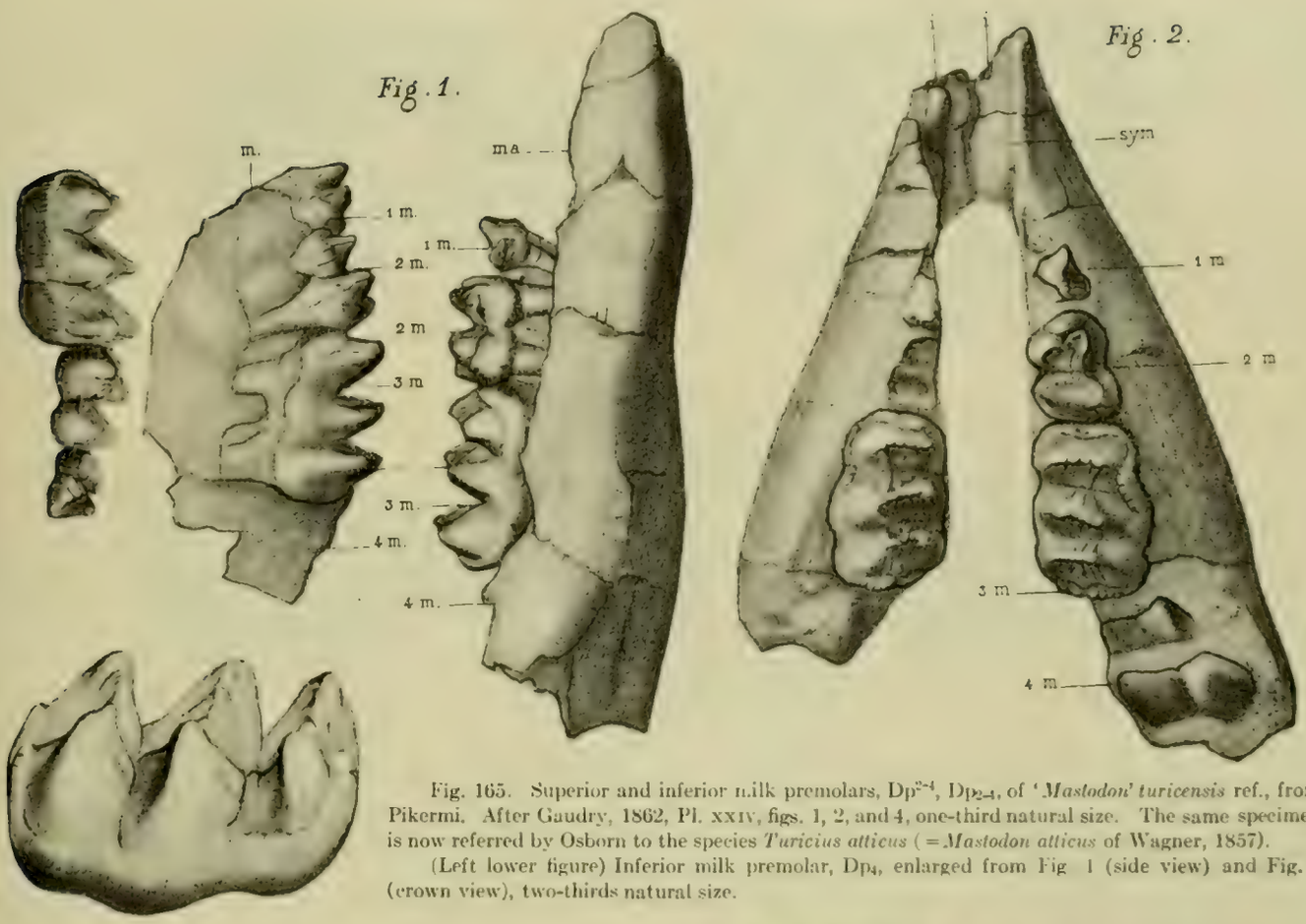


Fig. 165. Superior and inferior milk premolars, Dp^{2-4}, Dp_{2-4}, of '*Mastodon*' *turicensis* ref., from Pikermi. After Gaudry, 1862, Pl. XXIV, figs. 1, 2, and 4, one-third natural size. The same specimen is now referred by Osborn to the species *Turicius atticus* (=*Mastodon atticus* of Wagner, 1857).

(Left lower figure) Inferior milk premolar, Dp_4, enlarged from Fig. 1 (side view) and Fig. 2 (crown view), two-thirds natural size.

Lower Jaw.—(7) Symphysis abbreviated, recalling that of *M. americanus*, its upper face deeply hollow, the rami broad and shallow; (8) small inferior milk incisors (Di_2) similar to those of *M. americanus*, probably deciduous; (9) first inferior molar (Dp_2) primitive, elongated, laterally compressed, composed of a prominent cone and two posterior conelets; second inferior molar (Dp_3) with double crests, third inferior molar (Dp_4) with three very distinct crests and external trefoil spur (*arête*) on each crest; (10) no trace of vertical succession by permanent molars, again resembling *M. americanus*. The above progressive and retrogressive characters of the milk teeth serve to separate *Turicius atticus* very positively from *T. turicensis* (*typicus*) and geologically preceding stages.

Turicius virgatidens von Meyer, 1867

Figures 167, 168, also Pl. III H, H1–H3

Type: Middle(?) Pliocene, 'Gelben Lehme' bei Fulda, northeast of Frankfort, Germany. Referred: Middle Pliocene, Murinsel, Croatia, and Laaerberg, Austria

Mastodon virgatidens von Meyer, 1867. "Studien über das Genus Mastodon." Palaeontographica, Band XVII, 1867–1870, pp. 61–63. Type (fide von Meyer).—A right third lower molar, r.M_3, a second right lower molar, r.M_2, and a second left upper molar, l.M^2. Horizon and Locality.—'Gelben Lehme' bei Fulda, northeast of Frankfort, Germany; Middle(?) Pliocene. Type Figure.—*Op. cit.*, Taf. IV, figs. 1–5.

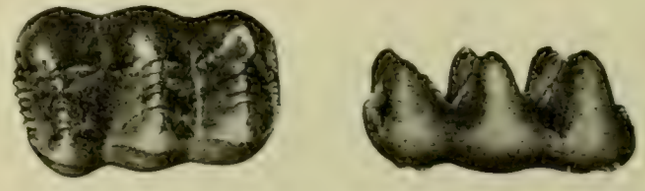
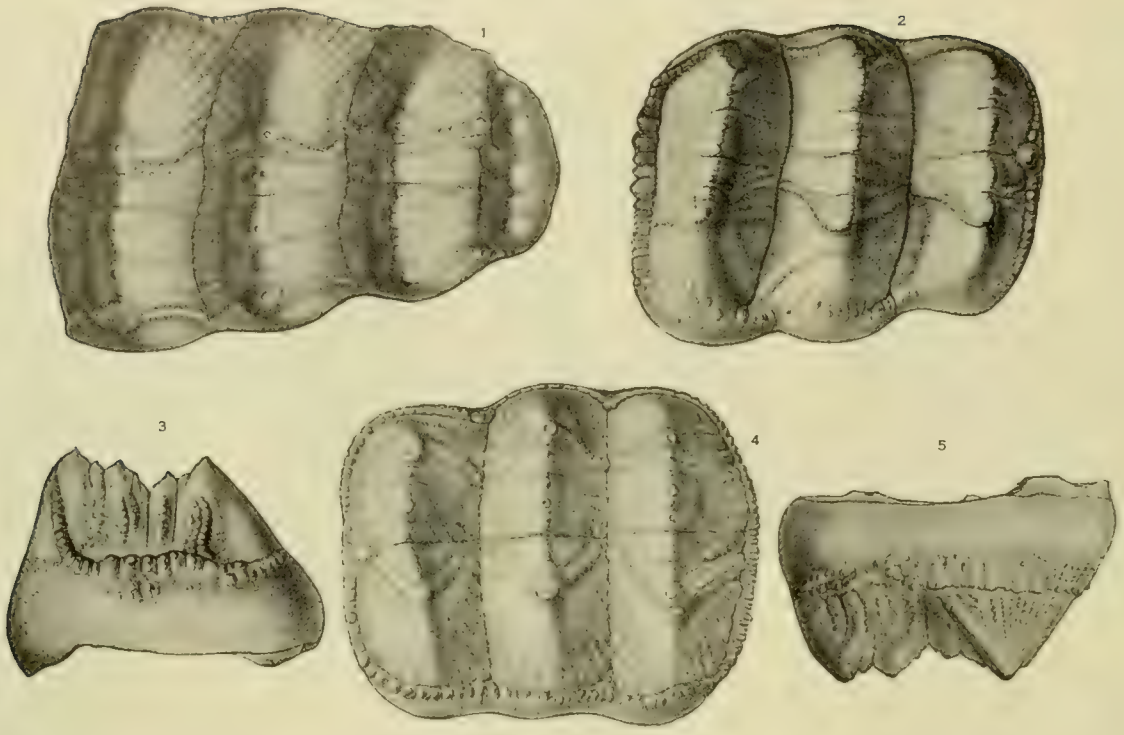


Fig. 166. Compare *Turicius virgatidens* (Fig. 168). A lower molar, l.M_2, from Murinsel, Croatia, referred by Vacek to *Mastodon tapiroides* [=*Turicius turicensis*], but which appears to be closer to the stage *Turicius virgatidens*. After Vacek, 1877. Taf. VII, figs. 4, 4a, one-third natural size. Same as figure 140

Fig. 167. Anterior aspect of protoloph of *Turicius*, after Schlesinger, 1913, fig. 2, p. 718, one-half natural size

(Left) *Turicius virgatidens* ref., Middle Pliocene, Terrasse vom Laaerberg, Austria.

(Right) Referred *Turicius* (?) *tapiroides* Middle Miocene, Faluns de la Touraine, France, Helvétien



TYPE OF TURICIUS VIRGATIDENS

Fig. 168. Type molars of *Mastodon virgatidens* von Meyer, 1867, Taf. IV, figs. 1–5, one-half natural size. From 'Gelben Lehme' bei Fulda, northeast of Frankfort, Germany.

Taf. IV, fig. 1 (*op. cit.*, p. 62): "Letzter Backenzahn der rechten Unterkieferhälfte." Taf. IV, figs. 2, 3: "Vorletzter Backenzahn der rechten Unterkieferhälfte." Taf. IV, figs. 4, 5 (*op. cit.*, p. 63): "Vorletzter Backenzahn aus der linken Oberkieferhälfte."

Fig. 1. Third inferior molar of the right side, r.M_3; figs. 2 and 3, second inferior molar of the right side, r.M_2; figs. 4 and 5, second superior molar of the left side, l.M^2.

This final stage of *Turicius* seems to be rare; besides the type from Fulda, Germany, we observe one tooth from Murinsel, Croatia (Fig. 166), which may be referable to the same species. Schlesinger (1913, p. 716) also described from the locality of Laaerberg, "Mittelpliocän, Terrasse vom Laaerberg," a large tooth which he regards as transitional between *Zygolophodon tapiroides* Cuv. and *Z. borsoni* Hays and which (p. 720) he likens to *Tetrabelodon virgatidens* (cf. Abb. 1, p. 716, Abb. 2, p. 718, and Abb. 3, p. 720); this Laaerberg animal, which Osborn is inclined to regard as resembling *Turicius virgatidens* more closely than the typical *Zygolophodon borsoni*, appears to confirm the Middle Pliocene age of *T. virgatidens*.

GEOLOGIC AGE.—The uppermost Miocene age attributed by Sandberger and von Meyer probably corresponds with the Middle(?) Pliocene age according to more recent correlation; certainly *Turicius virgatidens* is much more progressive than the *Turicius atticus* of the Pikermi stage.

The geologic age of this very important species is not determinable from von Meyer's description. The characters of the grinding teeth appear to represent a stage considerably more progressive than that from the Lower Pliocene of Pikermi, namely, *Turicius atticus*. Vacek (1877, p. 7) observes: "Die Reste desselben stammen aus einem gelben Lehme bei Fulda, . . . den aber in neuerer Zeit Prof. Sandberger in seinem schönen Werke über die Süsswasser-Conchilien (synchr. Taf.) als oberstes Miocän anführt."

Vacek (*op. cit.*, pp. 7 and 8) cites von Meyer's characterization of this species and compares it closely with *Mastodon borsoni* and *M. tapiroides*, i.e., *'M'. turicensis*, but fails to perceive the fundamental distinctions in the character of the ridge-crests and in the multiplication of the conelets, especially in M^2-M_2 (Fig. 168, 2, 4), which clearly distinguish the species *'Mastodon' virgatidens* from any less progressive species in the *Turicius* phylum.

TYPE DESCRIPTION.—Von Meyer characterizes these teeth as follows (von Meyer, *op. cit.*, 1867, p. 61): "Die Backenzähne sind von ausgezeichneter Schönheit; die beiden vorletzten sind dreireihig, einen Trilophodonten verrathend, dessen Zähne sich nur denen in Mastodon Turicensis vergleichen lassen. Sie sind aber womöglich von noch einfacherer Bildung und etwas grösser als die von Elgg, namentlich verhältnissmässig breiter; die Querreihen bestehen nicht aus Hübeln oder zitzenförmigen Theilen, sie gleichen mehr Querkämmen und sind eher noch schärfer und flacher, die Querthäler den Kämmen entsprechend tiefer und schärfer eingeschnitten und noch freier, und die Hälften der Querkämme deutlicher getrennt als in M. Turicensis. . . . Die Wulstkanten der Haupthügel sind zwar deutlich aber eher schwächer, und zwischen denen der Aussen- und Innenseite besteht kein so deutlicher Unterschied in Stärke als in M. Turicensis. Die durch das Ineinandergreifen der gegenständigen Kronen bedingte Abnutzung ist daher mehr mit Zuschärfung der Kämme verbunden, als dass kleeblattförmige oder ovale Kauflächen entständen. Bei

den oberen Backenzähnen verlaufen die Haupthügel der Innenseite, bei den unteren Backenzähnen die Haupthügel der Aussenseite wulststreifig gegen ihre Basis hin, was wohl bei längerem Gebrauche der Zähne an Deutlichkeit verloren haben würde, aber doch entschieden dazu beiträgt, diesen Zähnen ein eigenthümliches Gepräge zu geben.

Osborn, 1925: Von Meyer rightly describes these beautifully preserved types as more sharply lophodont than the *M. turicensis* type, the 'wulstkanten' (='mamelon') being sharply compressed; the teeth are *broader* and *shorter* than those of *M. turicensis;* the superior tusk ('stosszahn') is described as 5¼ feet long, of oval section, entirely devoid of enamel coating or enamel band, greatly exceeding in size the tusk referred to *M. turicensis*—all of which leads von Meyer (*op. cit.*, p. 63) to conclude: "Ich habe daher diese Zähne unter dem Namen Mastodon virgatidens begriffen."

Turicius wahlheimensis Klähn, 1922

Figure 229, also Pl. III J

From Wahlheim and Esselborn, Rheinhessen, Germany. Pliocene.

For brief description and figure, see page 282, fig. 229, of the present Memoir.

8. GEOGRAPHIC DISTRIBUTION AND EXTINCTION OF SPECIES OF TURICIUS

Compare Pl. III A–J, pp. 134–135

As fully described in the previous pages, *Turicius* occurs successively in the Lower Miocene of France, age of the Sables de l'Orléanais, Calcaire de Montabusard, and Faluns de Pontlevoy, clearly enumerated by Mayet (1908). It occurs in the Middle Miocene of Sansan and Simorre, as described by Lartet, and of Styria, as described by Schlesinger, also in the Upper Miocene lignites of Switzerland, as described by Schinz, von Meyer, and other authors. In all these Miocene stages the cones and conelets are more or less separate, rounded, and distinct at the summit. In the Lower Pliocene stage (*Turicius atticus*), fully described and figured by Wagner as *'Mastodon' atticus* and by Gaudry as *'Mastodon' turicensis*, the conelets become connate at the summit. This sharply connate character is still more accented in the *Turicius virgatidens* of von Meyer; the type tooth is sharply zygodont, which reminds one of some of the Pliocene stages of *Stegodon*, although the conelets (Fig. 168, 2) are much smaller and also less numerous than in the progressive *Stegodon* of India. *Turicius* apparently survived until the Middle Pliocene (Pliocène ancien), but no trace of species of this *Turicius* phylum has been found in Upper Pliocene beds containing remains of *Z. borsoni.*

Distinction from Serridentinus.—These zygolophodont progressive tendencies in *Turicius* and the development of a pure transverse crest, to which the name *Zygolophodon* so clearly applies, is quite distinct from the development of the corresponding conelets and crests in the American *Serridentinus* in which the cones and conelets do not become connate and remain quite distinct at the summit. The second distinction of *Serridentinus* is the progressive strengthening of the 'trefoil spurs,' which become more and more prominent and conspicuous in progressive stages, surmounted with small conelets, whereas in progressive stages of *Turicius*, like *T. atticus* and *T. virgatidens*, the 'trefoil spurs' are reduced to fine ridges accented with numerous small conelets. Thus while there is a strong resemblance in the Miocene stages between species of *Serridentinus* and species of *Turicius*, there is very little resemblance between final species in these two phyla which are very widely divergent. This becomes clear in the following treatment of *Serridentinus* (Chap. X).

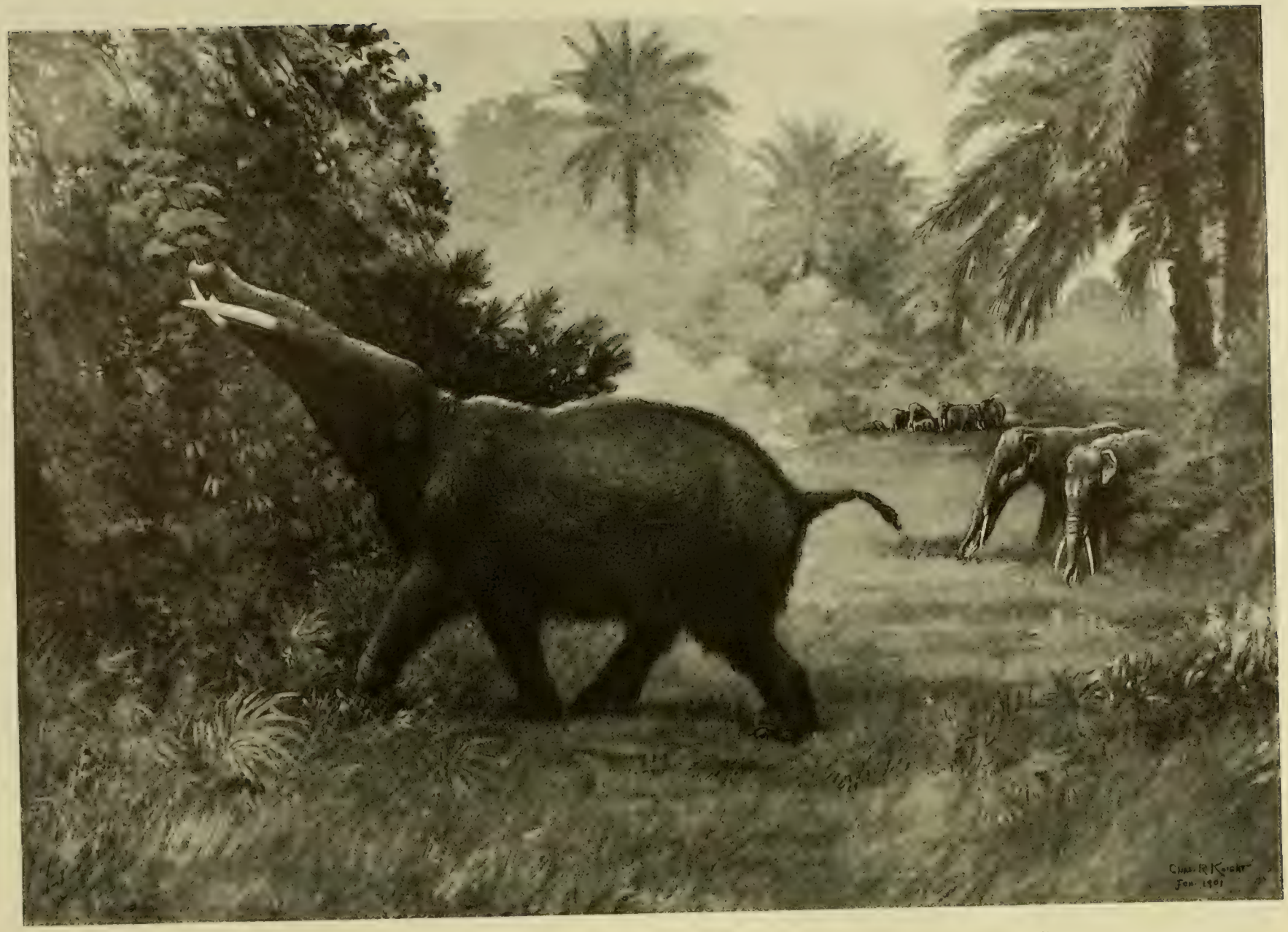


Fig. 169. Restoration (1901) of the Long-jawed Trilophodon, the Classic 'Mastodon' angustidens of Cuvier

By Charles R. Knight, under the direction of Henry Fairfield Osborn

After Charles R. Knight's original drawings of the skull and jaws in the Paris Museum (see Figs. 199, 200)

This beautiful drawing was executed by Knight in 1901, six years prior to the researches by Osborn which revealed evidence of a relatively abbreviated proboscis in *Trilophodon* as compared with the elongated, flexible proboscis of elephantine form represented by Knight in the present restoration. The brilliant white ivory tusks of these Trilophodonts are in accord with photographs of the modern elephants.

Chapter VIII

HISTORY OF THE SUBFAMILIES LONGIROSTRINÆ AND AMEBELODONTINÆ. ORIGIN AND GEOGRAPHIC DISTRIBUTION OF THE LONG-JAWED MASTODONT PHYLA

Separation of the 'true bunomastodonts' of the family Bunomastodontidæ. Characters of the five[1] bunomastodont subfamilies, the longirostrines, serridentines, rhynchorostrines, notorostrines, and brevirostrines. Phyletic history and migrations of the extremely long-jawed phiomia-amebelodon, also of trilophodon. Dental succession in the longirostrines and other mastodonts.

1. Characters of the family Bunomastodontidæ and separation of this family into nine[1] distinct subfamilies.
2. Characters of the subfamilies Longirostrinæ and Tetralophodontinæ.
3. Dental succession in the Longirostrines and other mastodonts (see also p. 230).
4. Generic characters of *Phiomia* and its division into three to four progressive species, *P. minor*, *P. serridens* (=*wintoni*), *P. wintoni*, *P. osborni*.
5. Transition from *Phiomia osborni* to *Phiomia pygmæus*.
6. History and characters of the genus *Trilophodon* Falconer; chronological order of discovery and description of the forty actual or related species of *Trilophodon*.
7. Typical *Trilophodon angustidens* of Cuvier including European and African stages. Separation from *Serridentinus*.
8. *Trilophodon* (*Choerolophodon*) of southeastern Europe (Pikermi, Samos), and of Asia (Maragha, Persia).
9. Asiatic species of *Trilophodon*, chiefly of Middle and Lower Miocene age. Evolution of the central conules (pp. 276–278).
10. Trilophodonts or Serridentines of Japan.
11. Miocene and Pliocene mastodonts of Baden and Rheinhessen, Klähn, 1922 (p. 281).
12. The Lower Miocene Trilophodont of France (*Trilophodon pontileviensis*) compared with the primitive *Trilophodon cooperi* of Baluchistan.
13. Migration of Eurasiatic *Trilophodon* at the close of the Miocene.
14. Brachyodont, forest-loving species of the east coast of North America.
15. 'Uproot-tuskers' of Kansas, Nebraska, South Dakota, Colorado, and New Mexico (p. 288).
16. Review of the Frick Collection of Trilophodonts, 1924–1933.
17. Summary of the origin and phylogenetic succession of the Trilophodonts.
18. Discovery and description of the 'shovel-tuskers' (*Amebelodon*, 1927), successors to *Phiomia osborni*.

Appendix. Cuvier's type of *Mastodon angustidens*. Central conules distinctive of *Trilophodon*.

(December, 1933). The epoch making discovery of the 'shovel-tuskers' of eastern Eurasia and of North America, subsequent to the completion of the main portion of the present Chapter (VIII), is fully described in Section 18, including the chief discoveries between the years 1927 and 1933. (October, 1934) Ancestral to the 'shovel-tuskers' (Amebelodontinæ) was the *Phiomia* of northern Africa (see Pls. V and VI between pp. 235 and 236).

This chapter is purposely comprehensive in order firmly to establish the distinctions of the Bunomastodontidæ from the Mastodontidæ, namely, in the blocking of the intermediate valleys by a *central conule* or a 'trefoil spur' which is wanting in the superior grinders of two primitive species, *Phiomia minor* and *P. wintoni* (cf. Fig. 179, B, A), but makes its appearance as a neomorph or rectigradation[2] in the inferior grinders of *P. wintoni* (Fig. 182 B1) and in the inferior grinders of *P. osborni* (Fig. 185, A1), probably also in *P. pygmæus* (Fig. 187 A). This very important *conule* reappears directly in the center of the valleys in the type of '*Mastodon*' *minutus* Cuvier (Fig. 191); it attaches itself to the *external* cones in the inferior molars, forming the outer trefoil, and to the *internal* cones of the superior molars, forming the inner trefoil, as shown in figure 190, Cuvier's type of '*Mastodon*' *angustidens*. This central conule of *Phiomia* and of *Trilophodon* (Figs. 185 and 195) and possibly of *Tetralophodon* is readily seen in the *unworn* condition of the grinding teeth and clearly distinguishes the grinding teeth of the Longirostrinæ from those of the Serridentinæ, in which there is no central conule but lateral spurs that gradually arise on the internal and external cones of the superior and inferior molars respectively. In the *worn* condition of the grinding teeth the molars of *Trilophodon* and of *Serridentinus* appear very much alike.

This important distinction is explained below in describing the subfamilies of the Bunomastodontidæ, also in the early part of Chapters IX and X. The progressive development of the grinding tooth pattern in the Bunomastodontidæ is illustrated in a comparison of the species arranged in ascending order of specific evolution under the four most highly characteristic genera, as follows:

[1](1935) See Appendix of present Volume for final classification of the Mastodontoidea. At date of going to press, the Bunomastodontidæ embrace seven subfamilies, namely, the Longirostrinæ, Amebelodontinæ, Tetralophodontinæ, Rhynchorostrinæ, Notorostrinæ, Brevirostrinæ, and Gnathabelodontinæ. The Serridentinæ and Platybelodontinæ have been removed to the Serridentidæ fam. nov., the Humboldtinæ to the Humboldtidæ fam. nov.

[2] 'Rectigradations' Osborn, 1908, are termed 'aristogenes' Osborn, 1932–1933.

Intermediate molars with three or four crests; shovel-shaped incisors *of Phiomia osborni* descent

Amebelodon
Trefoils progressive

Amebelodon fricki, etc.
'Shovel-tuskers' of Eurasia and America

Rudimentary or progressive *conules* in the median valleys. Third inferior grinders with three and a third crests. No trefoils. Crowns primitively brachyodont. *Central conules* progressive.

Phiomia Andrews
Phiomia pygmæus
Phiomia osborni
Phiomia wintoni
Phiomia serridens
Phiomia minor
Primitive 'shovel-tuskers' of the African Oligocene

Typically developed *conules* in the median valleys. Third inferior molars with four and a half to five and a half crests. Single external and internal trefoils persistent; bare rudiments of double trefoils. Crowns persistently brachyodont.

Trilophodon Falconer
Single trefoils
Trilophodon (Megabelodon) lulli
Trilophodon giganteus
Amebelodon (Trilophodon) hicksi
Amebelodon (Trilophodon) paladentatus
Trilophodon abeli
Trilophodon pojoaquensis
Trilophodon (Genomastodon) osborni
Trilophodon (Genomastodon) willistoni
Progressive species of the American Mio-Pliocene

Trilophodon angustidens cuvieri
Trilophodon angustidens var. *austro-germanicus*
Trilophodon pandionis
Trilophodon palæindicus
Trilophodon macrognathus
Trilophodon sendaicus
Trilophodon angustidens
Primitive and progressive species of Eurasia

Trilophodon angustidens libycus
Primitive species of Moghara, Egypt

Third inferior molars with five to eight and a third crests; intermediate molars with four crests. Double trefoils arising in inferior and superior grinders. Crowns brachyodont to subhypsodont, to hypsodont.

Tetralophodon Falconer
Double trefoils
Tetralophodon (Morrillia) barbouri
Tetralophodon campester
Tetralophodon elegans
Tetralophodon punjabiensis
Tetralophodon grandincisivus
Tetralophodon longirostris
Progressive species of the Pliocene of America and Eurasia

Tetralophodon (Lydekkeria) sinensis
(single trefoils)
Tetralophodon (Lydekkeria) falconeri
Primitive species of China and India

1. CHARACTERS OF THE FAMILY BUNOMASTODONTIDÆ AND SEPARATION OF THIS FAMILY INTO NINE[1] DISTINCT SUBFAMILIES

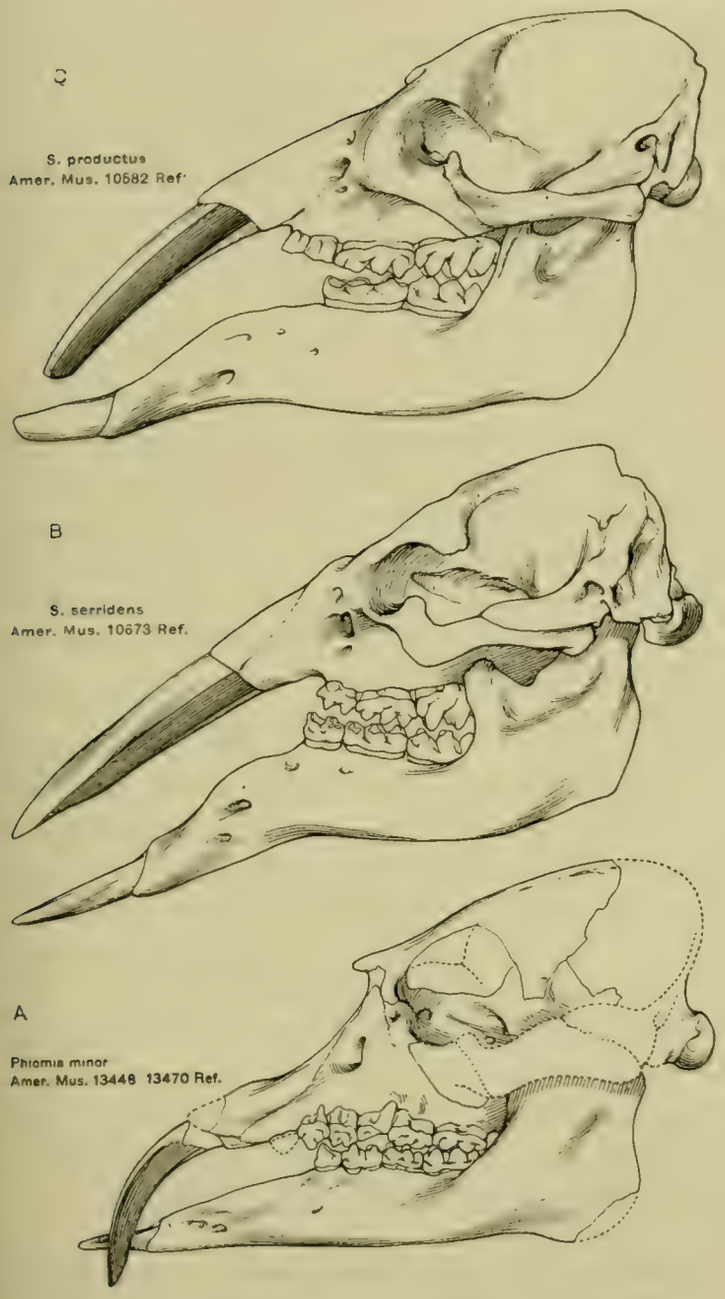
FAMILY: BUNOMASTODONTIDÆ Osborn, 1921

Original reference: Amer. Mus. Novitates, 1921, p. 2 (Osborn, 1921.515).

(1) As previously described in Chapter II of this Memoir, the family Bunomastodontidæ comprises the 'true bunomastodonts,' in which, as the two Greek words βουνός and μαστός indicate, the grinding teeth retain or progressively develop 'conules' and single, double, or quadruple 'trefoils' in the valleys between the transverse crests; whereas in the 'true mastodonts' the valleys between the transverse crests are uninterrupted by either 'conules' or 'trefoils.' Family characters arise independently in nine[1] subfamilies (see table, p. 228).

(2) This type of grinding tooth does not appear in primitive bunomastodonts like *Phiomia minor* (Fig. 179 B) or certain *Phiomia wintoni* (Fig. 179 A), but is clearly shown in progressive species like *Phiomia osborni* (Fig. 185) in which a large *conule* appears between the crests of P_4-M_3, and is shown to connect itself on prolonged wear with the *external* cones of the inferior molars, thus constituting a true *'external trefoil'*; this *conule* reappears in the grinding tooth of *Phiomia pygmæus* (Fig. 187 A), in which the summits of the cones subdivide into two 'conelets' as in all higher mastodonts. In certain lower grinders referred to *Phiomia wintoni* (Fig. 182 B1) these conules also appear, but they are absent in upper grinders referred to *Phiomia wintoni* (Fig. 179 A).

[1]See footnote on page 225.



PHIOMIA (A) AND SERRIDENTINUS (B, C) CRANIAL COMPARISON
SCALE NOT UNIFORM

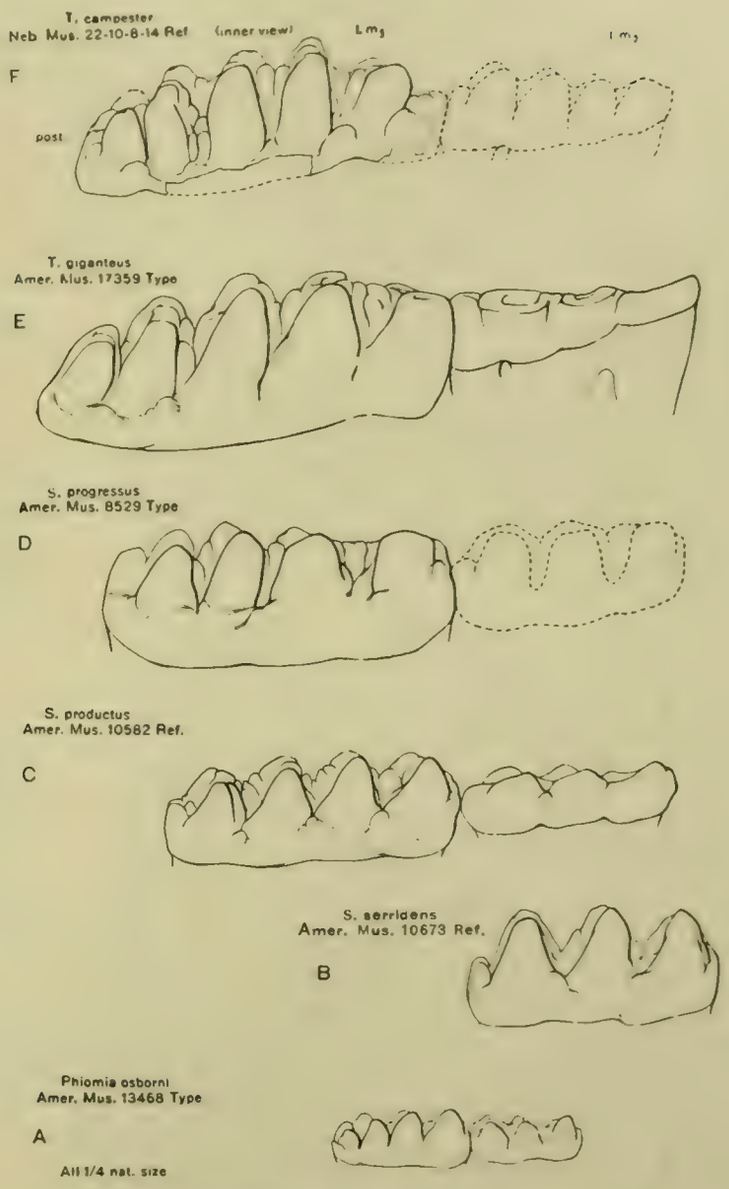
Fig. 170. Cranial profiles and lateral enamel bands in the African *Phiomia* and the American *Serridentinus*. Scale not uniform.

American Lower Pliocene. C, *Serridentinus productus* ref., Clarendon formation, Texas.

American Lower Pliocene. B, *Serridentinus serridens* ref., of Clarendon age, Texas.

N. Africa, Lower Oligocene. A, *Phiomia minor* (skull), *wintoni* (jaw). Fluvio-marine beds of the Fayûm, Egypt.

The *Phiomia minor* skull is about half the size of the two *Serridentinus productus* and *S. serridens* skulls; the proportions of the facial and cranial regions are very similar; the elongation of the jaws is practically similar and much less pronounced than in *Trilophodon angustidens*. These animals, therefore, are of medilongirostral type.



PHIOMIA (A), SERRIDENTINUS (B-D), TRILOPHODON (E), TETRALOPHODON (F). SCALE UNIFORM

Fig. 171. Evolution of the left second and third inferior molars in the Tetralophodontinæ, Longirostrinæ, and Serridentinæ. Uniform reduction scale of one-fourth.

F, *Tetralophodon campester* ref., Neb. Mus.; M_3 with $6\frac{1}{3}$ crests, M_2 with 4 crests.

E, *Trilophodon giganteus* type, Amer. Mus.; M_3 with $4\frac{1}{2}$ to 5 crests, M_2 with $3\frac{1}{3}$ crests.

D, *Serridentinus progressus* type, Amer. Mus.; M_3 with $4\frac{1}{2}$ crests, M_2 with 3 crests.

C, *Serridentinus productus* ref., Amer. Mus.; M_3 with $4\frac{1}{3}$ crests, M_2 with 3 crests.

B, *Serridentinus serridens* ref., Amer. Mus.; M_3 with $4\frac{1}{3}$ crests, M_2 with 3 crests.

A, *Phiomia osborni* type, Amer. Mus.; M_3 with $3\frac{1}{2}$ crests, M_2 with 3 crests.

Elongated Jaws, Functional Upper and Lower Tusks,	Abbreviated Jaws	Functionless Lower Tusks, Enamel Disappearing
'Long-jawed Bunomastodonts'	Serrate-toothed Mastodonts	'Beak-jawed Bunomastodonts'	'Notorostrines' and 'Humboldtines'[1] of South America	'Short-jawed Bunomastodonts'
Longirostrinæ	**Serridentinæ**[1]	**Rhynchorostrinæ**	**Notorostrinæ**	**Brevirostrinæ**
Functional upper and lower incisive tusks persistent. Lateral enamel band on upper tusks only.	Upper and lower tusks as in the Longirostrinæ. Lateral enamel band on upper tusks only.	Jaws partly abbreviated; compressed, downturned upper and lower tusks, each with lateral enamel band.	Loss of lower incisive tusks.	Rapid abbreviation of lower jaw; early loss of inferior tusks; superior tusks horizontal, upturned, without enamel.
Grinding teeth tetrabunodont, trilophodont, persistently brachyodont. Single or double trefoils. Central conules.	Serrated trefoils springing from the internal cones above, from the external cones below.	Symphysis of lower jaw downturned, hence 'beak jawed.'	Abbreviation of lower jaw and rostrum of skull.	Progressive double to quadruple trefoils on grinders, labyrinthine enamel, hypsodonty.
Amebelodontinæ	Jaws less elongated than in *Trilophodon*.	Grinding teeth shortened, with single trefoils.	1) *Cordillerion andium*, spiral-enamelled upper tusks, single trefoils.	1) *Anancus arvernensis*
1) *Phiomia*, with *central conules*, brachyodont, primitive, ancestral to *Amebelodon*.	1) *Serridentinus mongoliensis* 2) *Serridentinus productus* 3) *Serridentinus serridens*	1) *Rhynchotherium tlascalæ* 2) *Rhynchotherium cuhypodon* 3) *Rhynchotherium brevidens*	**Humboldtinæ**	2) *Pentalophodon sivalensis* 3) *Pentalophodon falconeri*
Tetralophodontinæ	4) *Ocalientinus floridanus* 5) *Serbelodon barbourensis*	4) *Rhynchotherium shepardi edensis*	1) *Cuvieronius humboldtii*, upturned, rounded upper tusks, without enamel, double trefoils.	4) *Synconolophus dhokpathanensis*
1) *Tetralophodon*, with double trefoils, becoming polylophodont, subhypsodont to hypsodont.	6) *Notiomastodon ornatus* **Platybelodontinæ**[1] 1) *Platybelodon grangeri*	5) *Blickotherium blicki* 6) *Aybelodon hondurensis*	2) *Cuvieronius ayoræ* 3) *Cuvieronius postremus*	'Humboldtines'[1] of North America **Humboldtinæ** 1) *Stegomastodon mirificus* 2) *Stegomastodon arizonæ* 3) *Stegomastodon aftoniæ*

(3) Another dental characteristic of all primitive bunomastodonts is the presence of a lateral enamel band on the superior tusks in apposition to the elongate and flattened inferior tusks which lack the enamel band. This betokens the primitive functional use of the upper and lower tusks in apposition, correlated with a grinding and triturating molar action rather than the chopping motion characteristic of the 'true mastodonts' (Fig. 172).

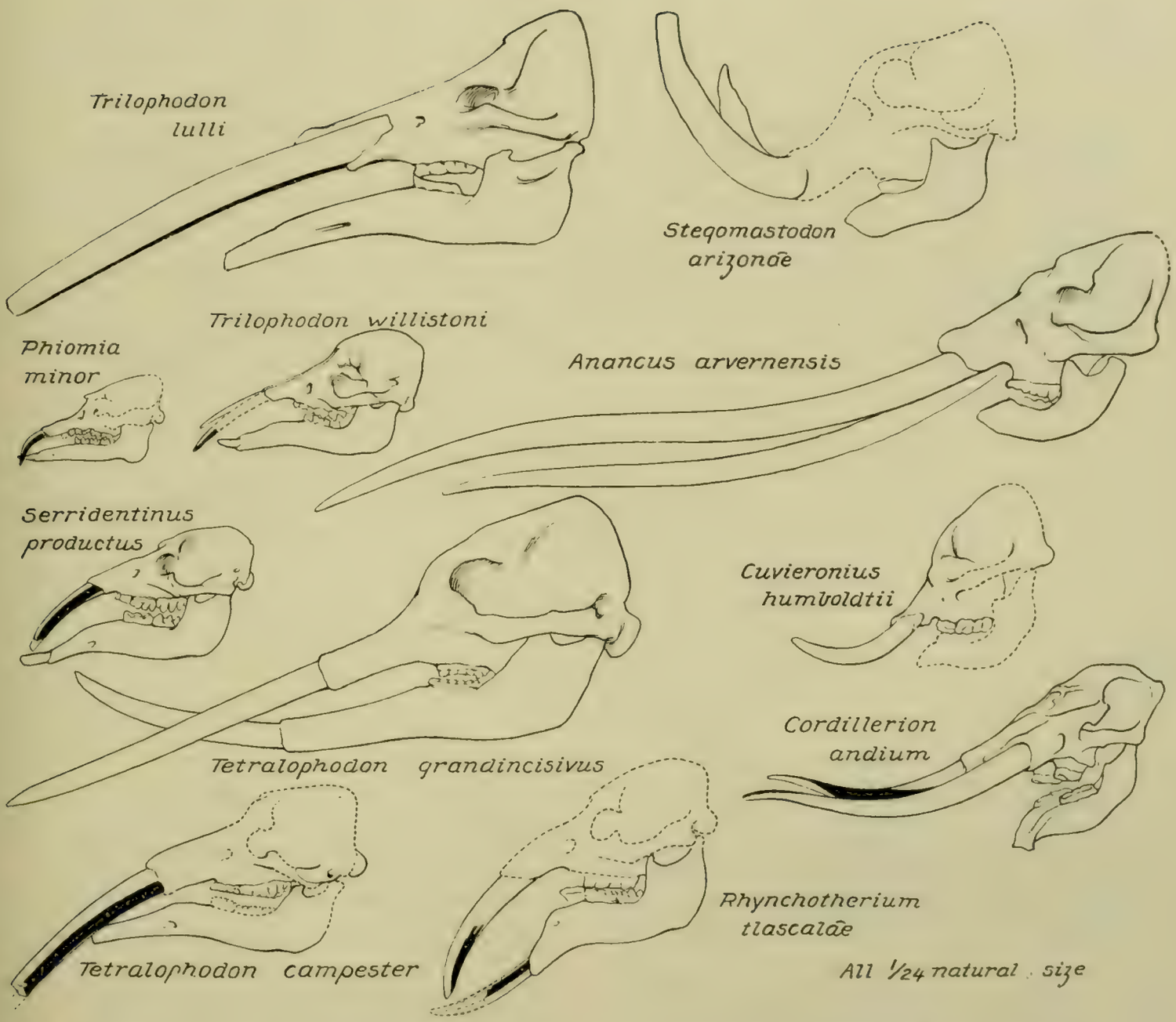
(4) This combined functional action of the tusks and grinding teeth arises in *Phiomia*, persists in the Longirostrinæ or 'long-jawed bunomastodonts,' in the Serridentinæ or 'medium-jawed mastodonts,'[1] and in the Rhynchorostrinæ or 'beak-jawed bunomastodonts.' The latter undergo a more or less parallel evolution, the original functions of the tusks and of the grinding teeth being retained, but with the progressive addition of double trefoils in the genus *Tetralophodon* of the Tetralophodontinæ (Fig. 172).

(5) In three of the subfamilies, namely, the Notorostrinæ, the Humboldtinæ,[1] and the Brevirostrinæ or 'Brevirostrines,' this original combined function is lost through the abbreviation of the jaw and the disappearance of the lower tusks. Once released from their cutting function with the lower tusks the upper tusks begin to rise, first retaining the enamel (*Cordillerion andium*), then losing the enamel and becoming upturned (*Cuvieronius humboldtii*[1]). In parallel evolution the 'short-jawed bunomastodonts' (Brevirostrinæ) lose their lower tusks at an early stage and develop long, projecting horizontal or upturned superior tusks without enamel (Fig. 172).

(6) By these mechanical methods the Bunomastodontidæ rose from small proboscideans similar to *Phiomia* of North Africa, probably frequenting the lowlands and swamps, adopting a browsing habit with their bunomastodont grinding teeth, and gradually differentiated into nine[1] subfamilies, members of which migrated throughout the entire Northern Hemisphere and gave off three branches,[2] which penetrated to the southern extremity of South America. We treat this subject of adaptive radiation and geographic distribution of the bunomastodonts more fully in Chapter XXI on "Affinities, Migrations, and Phylogeny of the Proboscidea." Meanwhile these nine[1] subfamilies may be clearly distinguished, as in the accompanying table.

[1]See footnote on page 225.

[2]Notorostrinæ, Humboldtinæ, and Serridentinæ (*Notiomastodon*).



DIVERGENT ADAPTIVE RADIATION OF CRANIA AND INCISIVE TUSKS IN SIX BUNOMASTODONT SUBFAMILIES. SCALE UNIFORM

Fig. 172. Comparative outline illustrations, side view, to same scale, of the completely restored skulls, jaws, and tusks, in descending order, of:

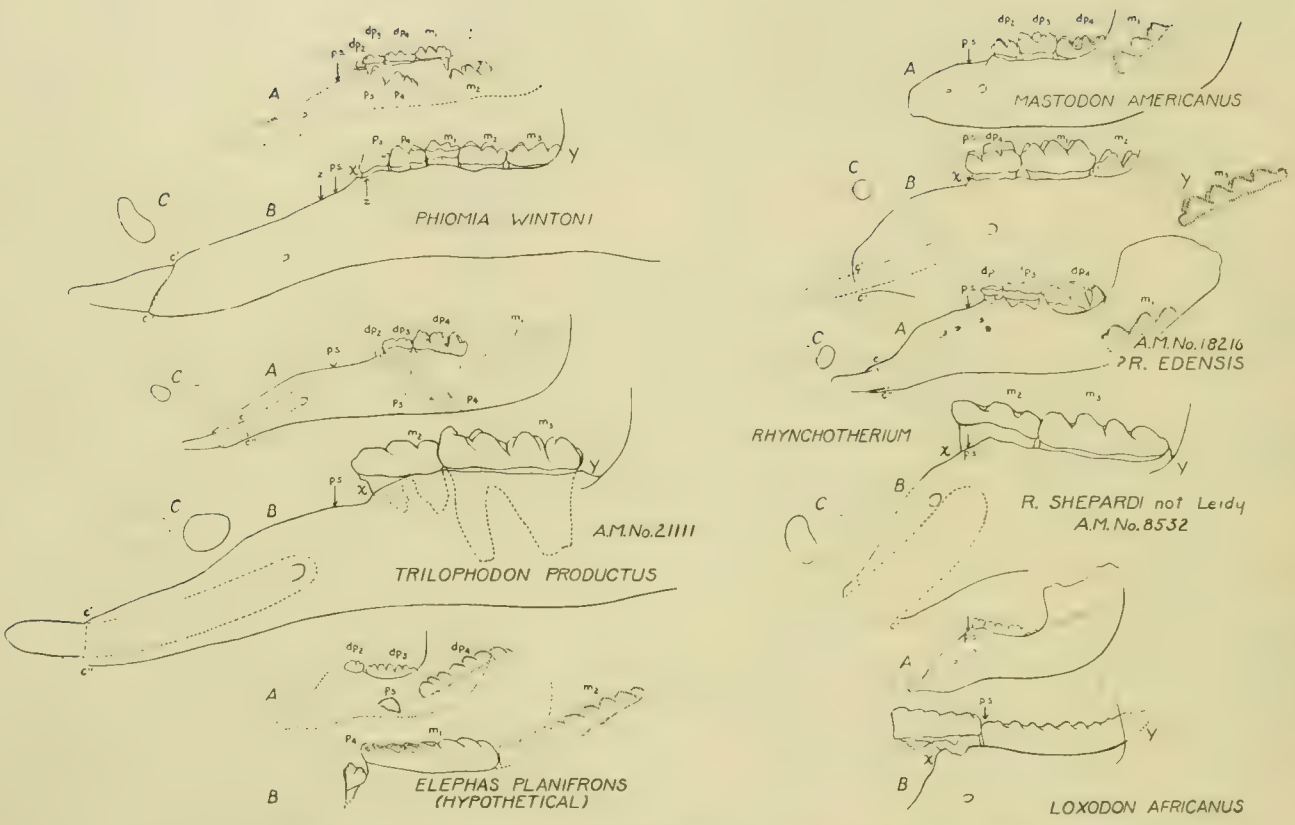
Trilophodon (*Megabelodon*) *lulli*[1]
Trilophodon (*Genomastodon*) *willistoni*, juvenile
Phiomia minor
Serridentinus productus
Tetralophodon grandincisivus
Tetralophodon campester
Rhynchotherium tlascalæ, restored

Observe persistent enamel band on *inferior* tusks, also apposition of inferior and superior tusks. In contrast with superior enamel band only in *Trilophodon*, *Phiomia*, *Serridentinus*, and *Tetralophodon*, and *absence* of enamel band on inferior tusks.

Stegomastodon arizonæ
Anancus arvernensis
Cuvieronius humboldtii, juvenile
Cordillerion andium

(Osborn, 1934) *Serridentinus* belongs in the new family Serridentidæ; *Stegomastodon* and *Cuvieronius* in the new family Humboldtidæ.

[1]The type mandible of *Trilophodon lulli*, originally restored by Barbour in 1914 with a pair of slender inferior incisive tusks (Fig. 244 of present Memoir), is now found to be tuskless. The rostrum is expanded at the tips. See Barbour, 1934.2.



DENTAL SUCCESSION: BUNOMASTODONTIDÆ AND ELEPHANTIDÆ. AFTER FRICK, 1926. SCALE NOT UNIFORM

Fig. 173. Dental succession in the Amebelodontinæ, Longirostrinæ, and Rhynchorostrinæ compared with that in the Elephantidæ. After Frick, 1926, p. 126, fig. 1C.

Phiomia wintoni

A, Juvenile jaw containing complete functional milk series, Di_2, Dp_2, Dp_3, Dp_4, also M_1; permanent premolars, P_3, P_4; M_2 partly buried in jaw.

B, Adult stage with adult functional dentition, I_2, P_3, P_4, M_1-M_3.

C, Incisors in section.

Trilophodon [=*Serridentinus*] *productus*

A, Juvenile jaw, partly hypothetical (compare juvenile *Phiomia wintoni*, also Amer. Mus. 21113 and 21112).

C, Incisors in section.

B, Adult mandible (Amer. Mus. 21111, neotype) containing M_2, M_3 only.

C, Incisors in section.

Elephas [=*Archidiskodon*] *planifrons*

A, Juvenile jaw, hypothetical.

B, Semi-adult jaw, hypothetical, P_4, M_1, M_2.

Both figures based on Falconer and Cautley, 1846 [1845], Pl. XII, figs. 8–11, and Pl. XIV, fig. 10.

Mastodon americanus

A, Juvenile jaw containing Dp_2-Dp_4. After Kaup, 1835, Pl. XX, fig. 1 (cast Amer. Mus. 10460).

B, Semi-adult jaw containing Dp_4, M_1, M_2; M_3 in jaw.

C, Incisors in section.

Rhynchotherium

A, (?) *R.* (*Dibelodon*) *edensis* Frick (Amer. Mus. 18216B), Eden Pliocene, Calif. [=*Rhynchotherium shepardi edensis* of the present Memoir]. Juvenile jaw, Di_2, Dp_2–Dp_4 *in situ*, M_1 in lower part of jaw.

B, *R. shepardi* [=*Rhynchotherium falconeri* Osborn, type] (Amer. Mus. Cope Coll. 8532), Blanco, Texas. Adult jaw, M_2, M_3 in function.

C, Section of I_2.

Loxodonta africana

A, Semi-adult jaw containing functional M_2; M_3 still in jaw.

B, M_2 shedding, M_3 coming into use.

2. CHARACTERS OF THE SUBFAMILIES LONGIROSTRINÆ AND TETRALOPHODONTINÆ

Original reference: Bull. Geol. Soc. Amer., 1918, Vol. XXIX, p. 136 (Osborn, 1918.468), and "Contribution to the Knowledge of the Fossil Mammalian Fauna of Java," van der Maarel, 1932, p. 108.

SUBFAMILY CHARACTERS.—(1) Cranium uniformly abbreviated. (2) Rostrum, facial region, moderately elongated (medilongirostral) or rostrum elongated (longirostral). (3) Lower jaws extremely elongated (longirostral), moderately elongated (medilongirostral). (4) Superior incisive tusks downcurved, outcurved, persistently broad enamel band on concave outer suface. (5) Inferior incisive tusks without enamel, progressively spatulate or flattened, persistent (*Trilophodon*), undergoing reduction (*Tetralophodon*); abrading dentine on inner side of superior enamelled tusks. (6) Grinding teeth brachyodont, with single trefoils, intermediate grinders trilophodont (*Phiomia,Trilophodon*); intermediate grinders tetralophodont (*Tetralophodon*), with double trefoils, subhypsodont to hypsodont. (7) In final phyletic stages the grinding tooth action concentrated on third superior and inferior molars, M^3, M_3; in primitive forms (*Trilophodon angustidens*), two or three grinders persisting in action. (8) Progressive suppression or retrogressive suppression of true premolar teeth, $P^{2\text{-}4}$,$P_{2\text{-}4}$, in upper and lower jaws, in contrast to the Serridentinæ. (9) Double trefoils slowly evolve in *Trilophodon*.

This subfamily of long-jawed bunomastodonts was originally regarded as monophyletic, that is, it was generally believed that the Miocene genus and species first discovered (*Trilophodon angustidens*) passed into the Pliocene *Tetralophodon longirostris*. Following studies by Andrews and Matsumoto, Osborn demonstrates that the species *Phiomia osborni* is directly ancestral to *Amebelodon*. The typical *Trilophodon angustidens* of the Miocene does not give rise to *Tetralophodon longirostris* but passes into a long line of direct descendants in which the *Phiomia* and *Trilophodon* characters are progressively developed in the elongation of the jaws and in the persistent use of the lower tusks as an uprooting 'shovel-tusk' (Greek ἄμη, shovel, βέλος dart, and ὀδούς, tooth), hence the final stage *Amebelodon fricki* of Barbour. Consequently it appears (1935) that the Longirostrinæ are not monophyletic but diphyletic and that '*M.*' *longirostris* and related species belong to a distinct subfamily named by Maarel (1932) Tetralophodontinæ.

Longirostral Extreme = LONGIROSTRINÆ Osborn, 1918

Excessive elongation of the jaw, i.e., *hyperlongirostral.*
Single mesotrefoils in the superior and inferior grinders.
Persistent brachyodonty to subhypsodonty.
Persistent uprooting function of lower incisive tusks.

Trilophodon, Miocene and Pliocene of Eurasia and North America.

AMEBELODONTINÆ Barbour, 1929

Phiomia, Oligocene of North Africa.
Amebelodon fricki of Nebraska, a direct descendant of *Phiomia*.

Medilongirostral = TETRALOPHODONTINÆ Maarel, 1932

Moderate elongation of the lower jaw and of the rostrum of the cranium, i.e., *medilongirostral.*

Early development of double trefoils on superior and inferior grinders. Progressive addition of crests and trefoils in third superior and inferior grinders. Addition of fourth crest in certain of the intermediate grinders, e.g., Dp 4–M 2.

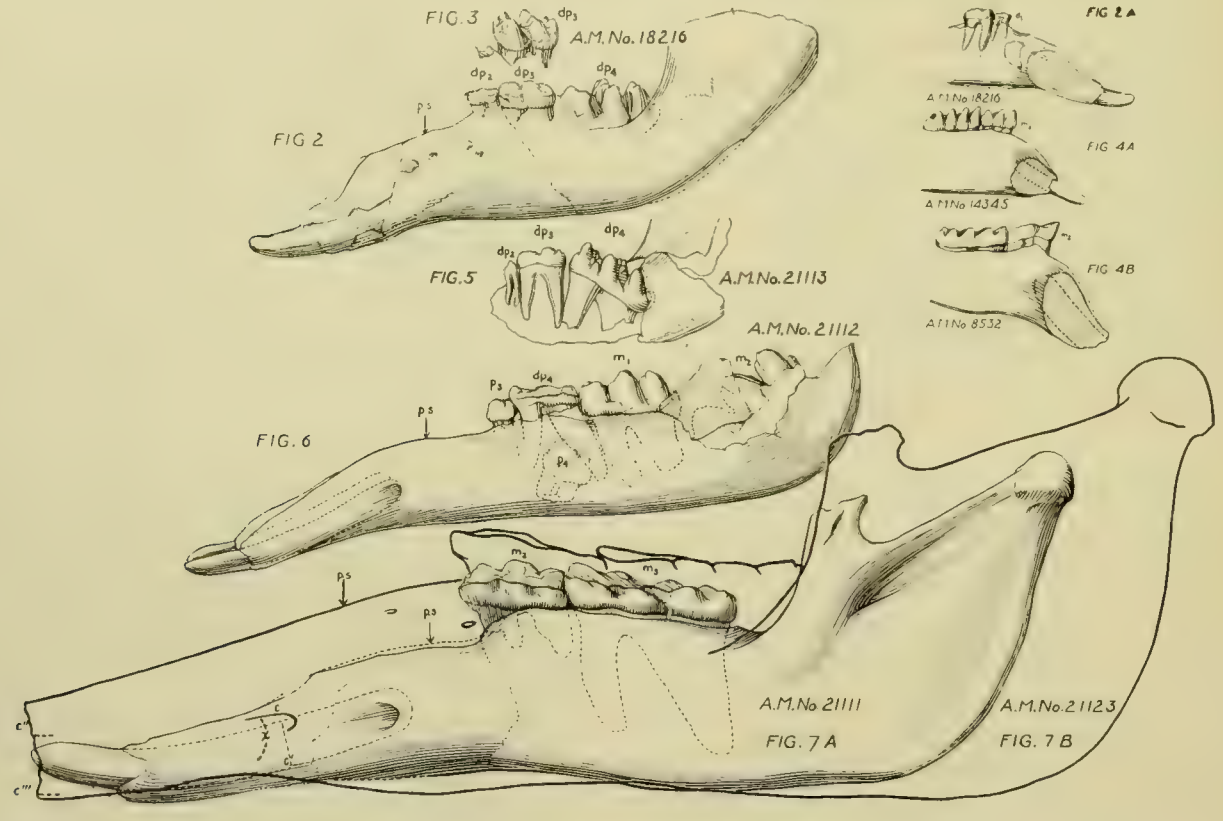
Subhypsodonty to hypsodonty, coronal cement on grinders.
Tetralophodon (Syn. *Tetrabelodon*), Pliocene of Asia and North America.
Lydekkeria, Miocene of southern Asia.
Morrillia, Middle Pleistocene of Nebraska.

With this explanation of a certainly diphyletic arrangement, we are able to define the subfamily Longirostrinæ by enumerating the characters common to all species of *Trilophodon:* the subfamily Tetralophodontinæ, as first distinguished by Maarel, by enumerating the characters of *Tetralophodon* (see also Chap. IX).

GEOLOGIC RANGE.—The long-jawed mastodonts compose numerous radiating phyla both geologically and anatomically, beginning with the numerous skulls of *Phiomia*, as well as the numerous skulls and partial skeletons of *Trilophodon angustidens* of the Miocene of France, and jaws and skulls of the Miocene and Pliocene of North America, continuing with the skulls and teeth of *Tetralophodon* of Europe, southern Asia, and North America; these long-jawed mastodonts appear to persist in savannas and forests until Middle or late Pliocene time.

Geographic Range.—Gervais, Gaudry, and Pomel (see Pomel, 1895, pp. 8 and 9) record from Barbary (comprising Morocco, Algeria, Tunisia, and Tripoli) *Mastodon* [= *Tetralophodon*] *longirostris* in the lacustrine beds of Smendou north of Constantine; *Mastodon* [= *Trilophodon*] *angustidens* at Djebel-Chirichira, west of Kérouan, Tunis; *Mastodon* [= *Turicius*] *tapiroides* from the region of l'Aurès—geographic determinations of importance which may bear on the probable African origin of the Longirostrines.

The Amebelodontines, as described below in the case of *Phiomia*, were probably savanna and stream-border dwellers, browsers rather than grazers. Tubers and leaves of trees were seized by pressing the elongated upper lip against the inferior teeth in *Phiomia*. The branches were drawn down by the sharpened superior tusks, which were also used as offensive and defensive weapons. The flattened lower tusks in *Phiomia* and *Trilophodon* were used in uprooting plants and smaller shrubs. The remarkable and rapid traveling powers



Dental Succession in Mastodon, Rhynchotherium, Serridentinus, and Trilophodon [=Ocalientinus]. After Frick, 1926

Fig. 174. Emergence and replacement of premolars and molars. After Frick, 1926, p. 128, with the substitution of specific determinations corresponding to those of the present Memoir.

(Figs. 2, 2A, 3) Amer. Mus. 18216 [B]. Referred ?*Rhynchotherium* (*Dibelodon*) *edensis* Frick [=*Rhynchotherium shepardi edensis* of the present Memoir]. Juvenile ramus, Pliocene of Eden, California.

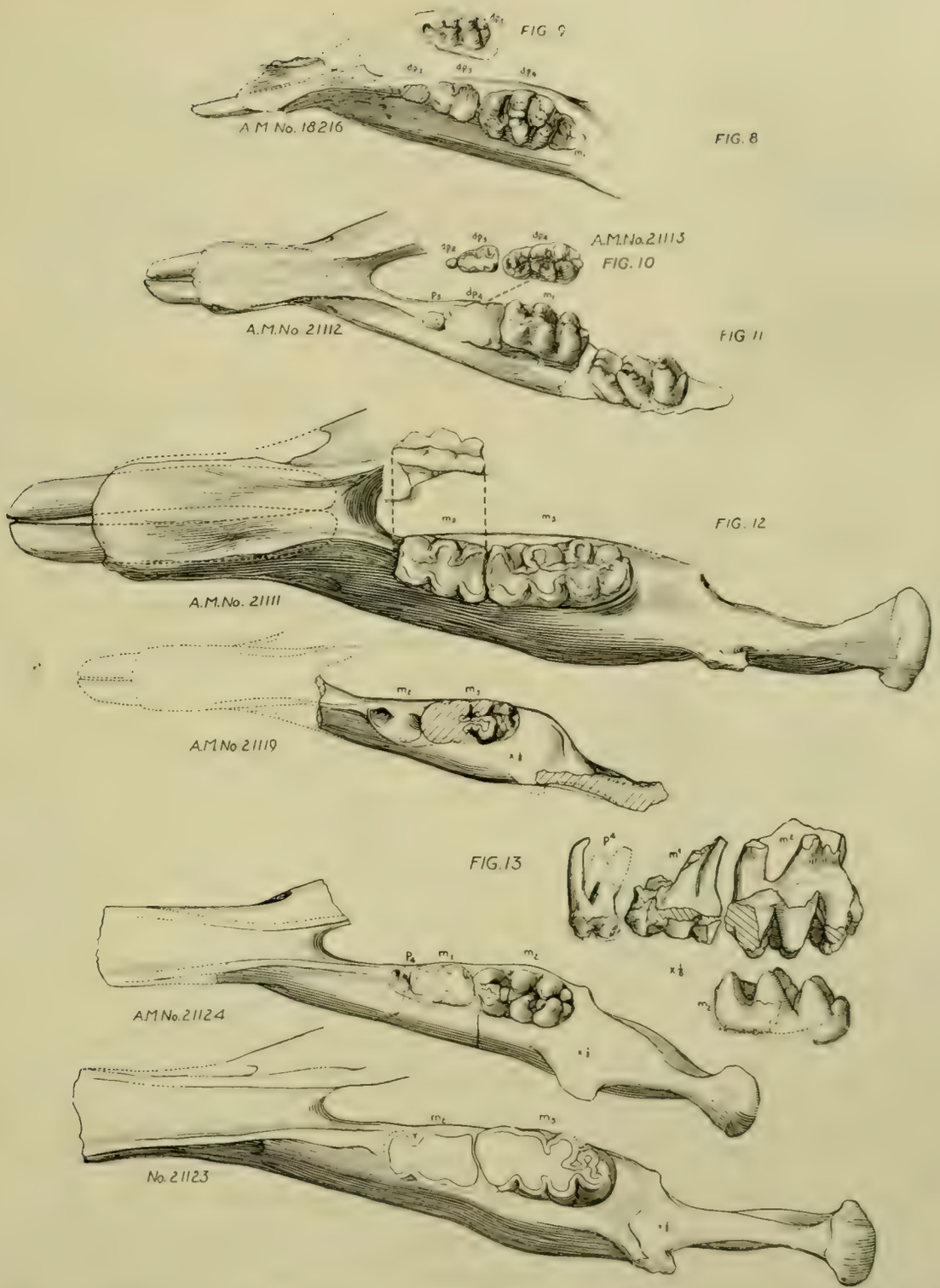
(Figs. 4A, 4B) Amer. Mus. 14345 (*Mastodon americanus*) and Amer. Mus. 8532 (type of *Rhynchotherium falconeri*) introduced for comparison.

(Fig. 5) Amer. Mus. 21113. Referred juvenile *Serridentinus productus*, Santa Fé marls, New Mexico.

(Fig. 6) Amer. Mus. 21112. Referred juvenile left ramus of *Serridentinus productus* showing unerupted P_4 and M_2.

(Fig. 7A) Amer. Mus. 21111. Adult *Serridentinus productus*, neotype. Santa Fé marls, New Mexico.

(Fig. 7B) Amer. Mus. 21123. Adult paratype jaw of *Trilophodon pojoaquensis* (1933, referred to *Ocalientinus ojocaliensis*) clearly showing the postsymphyseal (p.s.) region.



Dental Succession in Rhynchotherium, Serridentinus, and Trilophodon [=Ocalientinus]. After Frick, 1926

Fig. 175. Superior aspects of the mandibular rami and dentition of *Rhynchotherium*, *Serridentinus*, and *Trilophodon* [=*Ocalientinus*]. After Frick, 1926, pp. 132, 133, figs. 8–13. Figs. 8 to 12 one-sixth natural size; fig. 13 one-eighth natural size.

(Figs. 8, 9) Amer. Mus. 18216 [B]. *?Rhynchotherium* (*Dibelodon*) *edensis* Frick, Mt. Eden Pliocene, California [=*Rhynchotherium shepardi edensis* of the Memoir]. Deciduous tusks, Di_2, and premolars.

(Fig. 10) Amer. Mus. 21113. *Serridentinus productus*, Santa Fé marls, New Mexico. Referred juvenile dentition of right side, reversed.

(Fig. 11) Amer. Mus. 21112. *Serridentinus productus*, Santa Fé marls, New Mexico. Referred juvenile left ramus and symphysis.

(Fig. 12) Amer. Mus. 21111. *Serridentinus productus*, Santa Fé, New Mexico. Neotype adult left ramus.

(Fig. 13) Amer. Mus. 21119. *Serridentinus productus*. Referred left ramus. Santa Fé marls, New Mexico.

(Fig. 13) Amer. Mus. 21124. *Trilophodon pojoaquensis* [=(1933) *Ocalientinus ojocaliensis*], Santa Fé marls, New Mexico. External and internal views of referred superior and inferior grinders, P4-M2.

(Fig. 13) Amer. Mus. 21123. *Trilophodon pojoaquensis* [=(1933) *Ocalientinus ojocaliensis*], Santa Fé marls, New Mexico. Incomplete paratype mandible, lacking anterior rostrum.

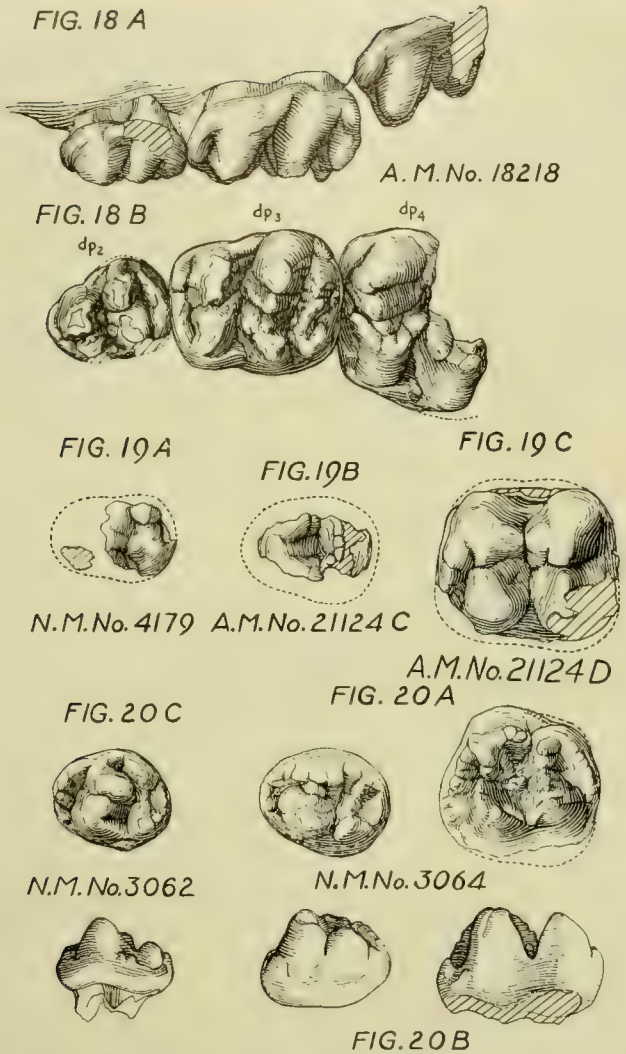


FIG. 176. DECIDUOUS PREMOLARS IN SERRIDENTINUS, TRILOPHODON [=OCALIENTINUS], AND RHYNCHOTHERIUM. AFTER FRICK, 1926

Deciduous premolars, Dp^2-Dp^4 of *Serridentinus*, *Trilophodon*, and *Rhynchotherium*. After Frick, 1926, p. 140, figs. 18A–20C.

(Fig. 18A) Amer. Mus. 18218. *?Rhynchotherium (Dibelodon) edensis* Frick, referred l.Dp^2-Dp^4. Eden Pliocene, California. (Fig. 18B) Crown views of same teeth. [=*Rhynchotherium shepardi edensis* of the present Memoir.]

(Fig. 19A) Nat. Mus. 4179. *Serridentinus productus*, referred r.P^3. Santa Fé marls, New Mexico.

(Fig. 19B, C) Amer. Mus. 21124C, referred r.P^3 of *Trilophodon pojoaquensis*. Amer. Mus. 21124D, referred r.P^4 of same species. Santa Fé marls, New Mexico. [=*Ocalientinus ojocaliensis* of the present Memoir.]

(Fig. 20A-C) Nat. Mus. 3064, type of *?Trilophodon (Serridentinus) leidii* Frick; crown and lateral views of r.P^{3-4} (germ). Nat. Mus. 3062, referred left P^3 of same species. Florida. =*Ocalientinus (Ser.) floridanus leidii* of the present Memoir.]

these Longirostrines and Amebelodonts from Africa, through Europe, Asia, and the west central United States as far south as Colorado, prove that they were well fed and well defended. There is no evidence for the Lull-Schlesinger theory that some of them were transformed by the abbreviation of the jaws into Brevirostrines.

3. DENTAL SUCCESSION IN THE LONGIROSTRINES AND OTHER MASTODONTS

Referring to the dental succession in *Mastodon americanus* (Chapter VI) and to the dental succession in *Archidiskodon planifrons* (Vol. II, Chap. XVI), the recent researches of Frick (1926) have completely clarified the previously obscure modes of dental succession in the Longirostrinæ as compared with other proboscideans. The *six* underlying adaptive principles are as follows:

(1) The precocious or accelerated development of the milk teeth, Di 2, Dp 2-Dp 4, including the molariform pattern of Dp 4, to meet the tender browsing and feeding habits of the juvenile stage, as in many other Herbivora.

(2) The retardation and final suppression of the replacing true premolars, P 2-P 4.

(3) The early eruption of M 1, early taking its functional place behind Dp 4.

(4) The retarded eruption of M 2 coincident with the shedding of Dp 2, Dp 3.

(5) The uniform cresting of the 'intermediate molars,' Dp 4-M 2, e.g., *three ridge-crests in Trilophodon and Serridentinus, four ridge-crests in Tetralophodon.*

(6) The greatly retarded eruption of M 3, with its multiple ridge-crests (4-6-8½), after all the premolars have been lost.

These *six* principles are admirably displayed in the accompanying diagrams by Frick (*op. cit.*, p. 126—Figs. 173–177 of the present Memoir).

The above diagram, which clearly sets forth the principles of premolar sequence, is followed in Frick's researches by numerous figures (Figs. 174, 175, 177 of the present Memoir) which illustrate in greater detail the actual structure of the tooth crowns and actual sequence of Dp_2 and M_1, M_2, also the symphyses and more or less complete jaws of *Serridentinus productus* and of *Rhynchotherium shepardi edensis*.

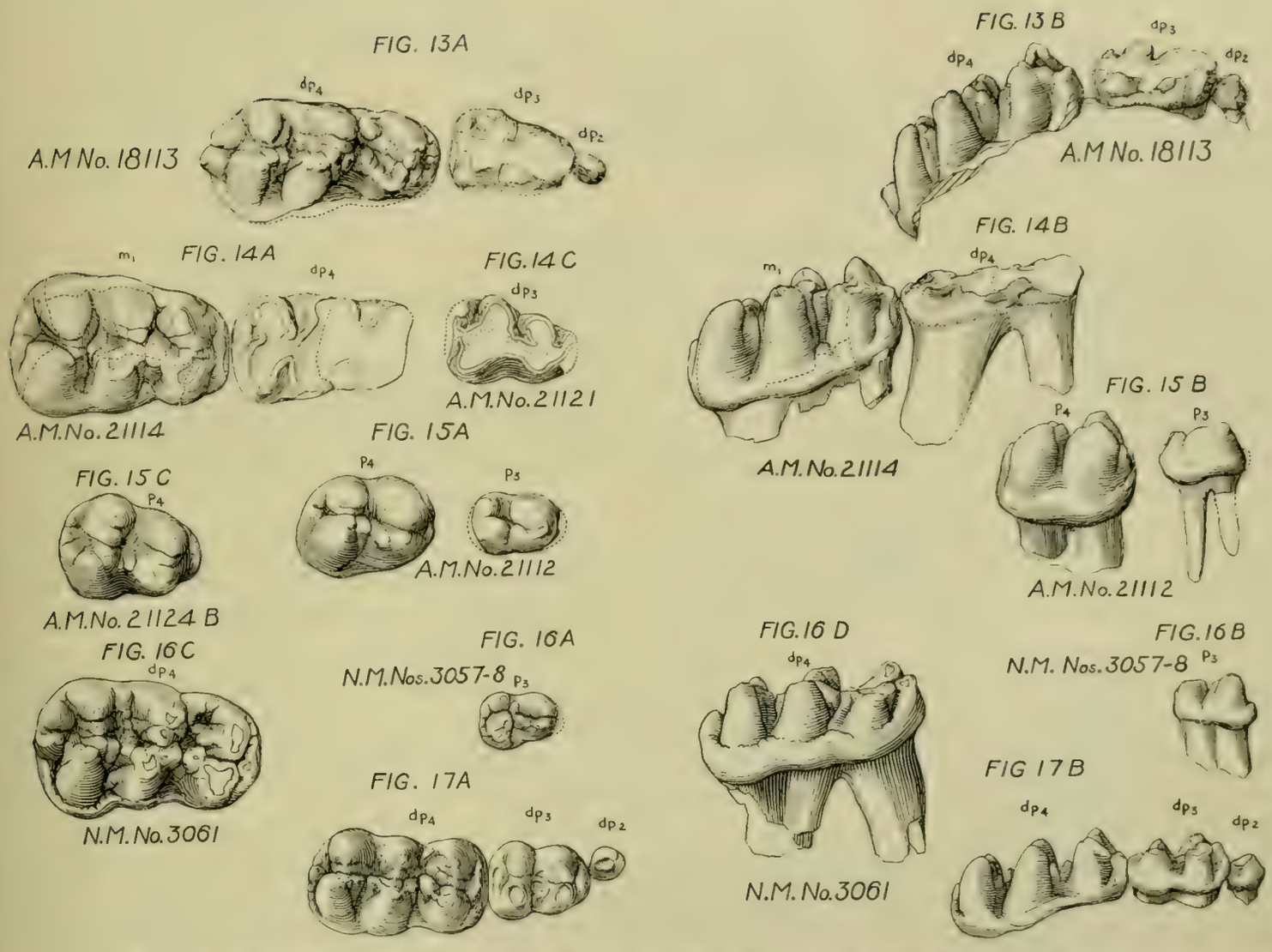


Fig. 177. Deciduous and Permanent Premolars in the Serridentinæ and Longirostrinæ. After Frick, 1926

Deciduous and permanent premolars, 2-4, of *Serridentinus productus*, *S. floridanus leidii*, *Trilophodon angustidens*, all one-half natural size. After Frick, 1926, pp. 136, 137, figs. 13A to 17A.

(Fig. 13A) Amer. Mus. 18113. Dp_2-Dp_4 of the right ramus of referred *Serridentinus productus*.

(Fig. 14A) Amer. Mus. 21114. Referred *Serridentinus productus*. Dp_4, M_1 of the right side.

(Fig. 14C) Amer. Mus. 21121. Referred *Serridentinus productus*. Dp_3 of the left side (reversed).

(Fig. 15C, A) Amer. Mus. 21124B and 21112. *Permanent* inferior premolars, $l.P_{3-4}$, of *Serridentinus productus*.

(Fig. 16C) Nat. Mus. 3061. Referred Dp_4 of *Trilophodon* (*Serridentinus*) *leidii* [=*Ocalientinus* (*Ser.*) *floridanus leidii*].

(Fig. 16A) Nat. Mus. 3057–3058. P_3 of the right side referred to same species.

(Fig. 17A) Referred *Trilophodon angustidens*, $r.Dp_{2-4}$. After cast Amer Mus. Warren Coll., Sansan, Miocene.

External and internal views of deciduous and permanent mandibular premolars, all one-half natural size. After Frick, 1926, pp. 136, 137, figs. 13B to 17B.

(Fig. 13B) Amer. Mus. 18113. Inferior deciduous premolars, $r.Dp_2$-Dp_4 (compare Fig. 13A).

(Fig. 14B). Amer. Mus. 21114. External view of $r.Dp_4$, $r.M_1$ (compare Fig. 14A).

(Fig. 15B) Amer. Mus. 21112. External view of *permanent* $l.P_3$-P_4 (compare Fig. 15A).

(Fig. 16D) Nat. Mus. 3061. External view of referred Dp_4 of *Trilophodon* (*Serridentinus*) *leidii* Frick (compare Fig. 16C). [=*Ocal.* (*Ser.*) *floridanus leidii*.]

(Fig. 16B) Nat. Mus. 3057–3058. External view of $r.P_3$ (compare Fig. 16A).

(Fig. 17B) Referred *Trilophodon angustidens*, $r.Dp_2$-Dp_4. Sansan, Miocene (compare Fig. 17A).

4. GENERIC CHARACTERS OF PHIOMIA AND ITS DIVISION INTO THREE TO FOUR PROGRESSIVE SPECIES

SUPERFAMILY: MASTODONTOIDEA Osborn, 1921

FAMILY: BUNOMASTODONTIDÆ Osborn, 1921

SUBFAMILY: AMEBELODONTINÆ Barbour, 1929

GENUS: **PHIOMIA** Andrews and Beadnell, 1902

Original reference: Surv. Dept., Pub. Works Ministry, Cairo, 1902, pp. 1-5.
Genotypic species: *Phiomia serridens* Andrews and Beadnell, 1902.

GENERIC CHARACTERS.—(Matsumoto, 1924.1, p. 3): "B.—Palate long and narrow. Symphysis long, its posterior end lying only a little anterior to, or posterior to the anterior end of the first cheek tooth (P_3); the most conspicuous one of the anterior mental foramina lying far anterior to the first cheek tooth, as well as to the posterior end of the symphysis. Ridge formula: $Dm\frac{1\cdot 2\ 3}{1\cdot 2\ 3}$. $P\frac{1\cdot 1\text{-}2}{1\cdot 2}$. $M\frac{3\cdot 3\cdot 2\text{-}3}{3\cdot 3\cdot 3\text{-}3}$. Last premolars and all molars typically bunodont; trefoil pattern of cusps well developed [*P. wintoni*, *P. osborni*]..... *Phiomia*."

This is a continuation of Chapter II, in which the original discovery and descriptions of the several species of *Phiomia*, the separation of this genus from *Palæomastodon* and *Mœritherium*, the habits and ancestral and phylogenetic relationships, the geologic succession, and the original type specimens and figures are fully recorded.

As pointed out clearly in Chapter II, Section III, the genus *Phiomia*, based on the genotype *Phiomia serridens* and since amplified by our present knowledge of the species *Phiomia minor*, *P. wintoni* Andrews and *P. osborni* Matsumoto, represents a group of species entirely distinct from species of the *Palæomastodon* group. Remains of the several species of *Phiomia* are found abundantly in the Fluvio-marine beds, Lower Oligocene, of the Fayûm, and are *eleven* times as numerous as specimens referable to *Palæomastodon*. Inasmuch as Andrews was misled by the paucity and the fragmentary nature of much of his material, his original (1902) and final (1906, pp. 169–171) definitions of the genus *Phiomia* and the genotype species *Phiomia serridens* became the cause of years of confusion both in Andrews' own splendid memoir (1906) and in all subsequent publications by Andrews, Osborn, Schlosser, and others, until the matter was supposedly set right by Matsumoto (1922.1, 1924.1), as fully set forth in Chapter II above, on the "Origin and Classification of the Proboscidea."

Osborn, 1934: The four species of *Phiomia* described above (pp. 55, 58, 60, 64) and below (pp. 239–246) are all 'shovel-tuskers' and now prove to be directly ancestral to the true 'shovel-tuskers' of the subfamily Amebelodontinæ of North America (see Pls. V and VI, pp. 235–236).

The above generic and phylogenetic characters are practically confirmed and amplified in the four species included within this genus and distinguished by measurement as follows:

Phiomia minor Andrews, 1904, cf. *'Phiomia' wintoni* in part	*Phiomia serridens* Andrews and Beadnell, 1902, cf. *Phiomia (?) wintoni*	*Phiomia wintoni* Andrews, 1905 = Syn. *Paleomastodon barroisi*	*Phiomia osborni* Matsumoto, 1922
Length of lower molar series, $M_{1\text{-}3}$, 145 mm.; of lower premolar-molar series, P_3-M_3, 201 mm.	Known from type and paratype inferior and superior milk dentition: Di_2, Dp^2-Dp_2, Dp^3-Dp_3, Dp^4, M^1.	Length of lower molar series, $M_{1\text{-}3}$, 166 mm.; of lower premolar-molar series, P_3-M_3, 236e mm. M_3 breadth-length index 53–59, average 55.5; M^3 breadth-length index 69–80, average 74.	Length of lower molar series, $M_{1\text{-}3}$, 172 mm.; of lower premolar-molar series, P_3-M_3, 246 mm. Central conules in M_2, M_3.

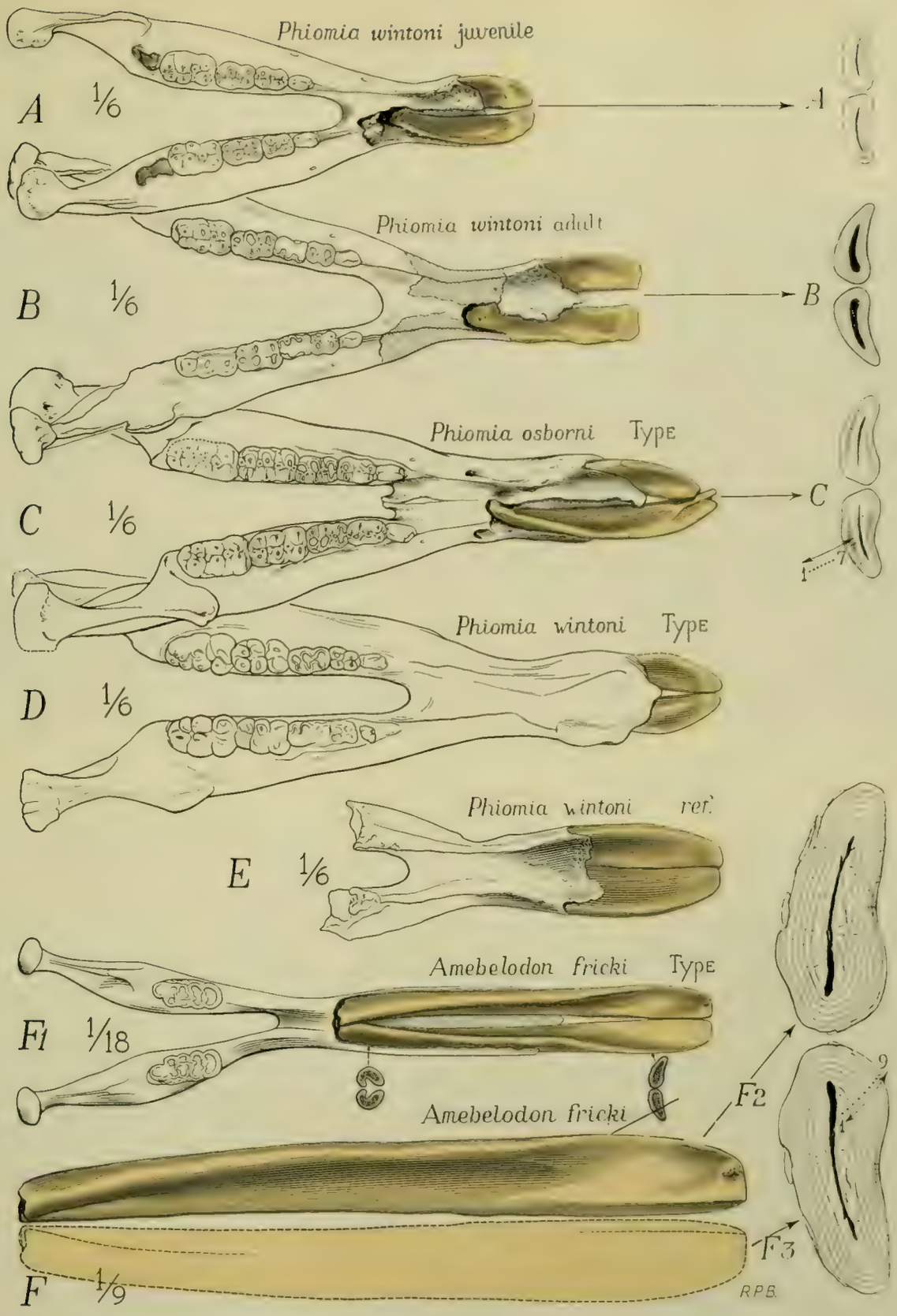


PLATE V

THE ANCESTRAL 'SHOVEL-TUSKER' PHIOMIA OF THE OLIGOCENE OF EGYPT EVOLVES INTO THE TYPICAL 'SHOVEL-TUSKER' AMEBELODON FRICKI OF THE MIDDLE PLIOCENE OF NEBRASKA. COMPARE PLATE VI

SEE ALSO APPENDIX FOR COMPARATIVE OBSERVATIONS

Mandibles A–E, one-sixth natural size; F1, one-eighteenth natural size; F, one-ninth natural size. Sections A–C, F2, F3, one-third natural size

A, Juvenile mandible of *Phiomia wintoni*, Amer. Mus. 13470. Length of mandible 520 mm., length of tusks 140 mm.

B, Adult mandible of *Phiomia wintoni*, Amer. Mus. 13471. Length of mandible 640 mm., length of tusks 180 mm.

C, Type mandible of *Phiomia osborni*, Amer. Mus. 13468. Length of mandible 680 mm., length of tusks 250 mm., weight of tusks 125 grams or 4.4 ounces. Section C, 7 laminæ of dentine (1–7), also central cavity as in *P. wintoni* (A) and in *A. fricki* (F2, F3).

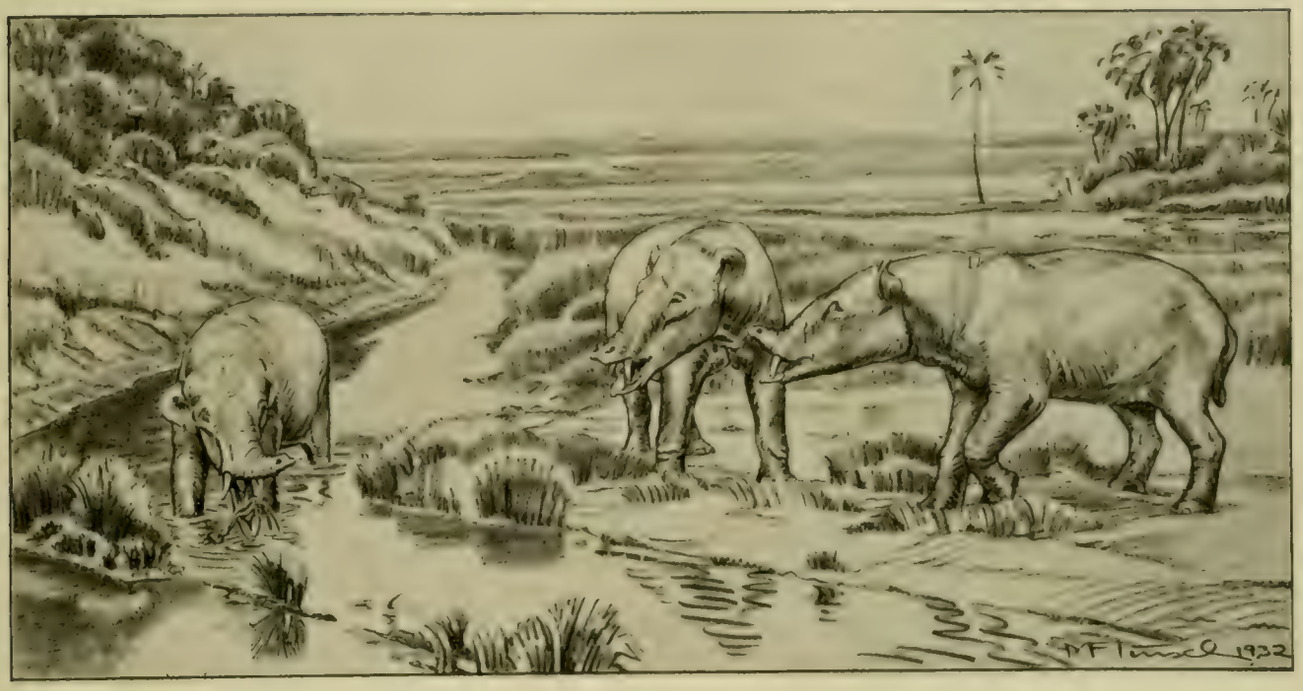
D, Type mandible of *Phiomia wintoni*, Brit. Mus. M.8414. Length of mandible 670 mm., length of tusks 240e mm.

E, Referred mandible of *Phiomia wintoni*, Brit. Mus. M.8476 (after Andrews, 1906, Pl. XIV, fig. 3). Length of tusks 260e mm.

F 1, Type mandible of *Amebelodon fricki*, Neb. Mus. 4–4–27. Length of mandible 1475 mm., length of tusks 1144 mm. Weight of tusks 10600 grams or 23 pounds, 6 ounces.

F, Type left lower tusk of *Amebelodon fricki*, Neb. Mus. 4–4–27, after cast in the American Museum, with outline of same tusk, reversed. The mass of the *Amebelodon fricki* tusk is more than seventy times as great as the mass of the *Phiomia osborni* tusk (C).

F2, F3, Type tusks of *Amebelodon fricki*, cross-section showing *nine* (1–9) laminæ of dentine, also central cavity as



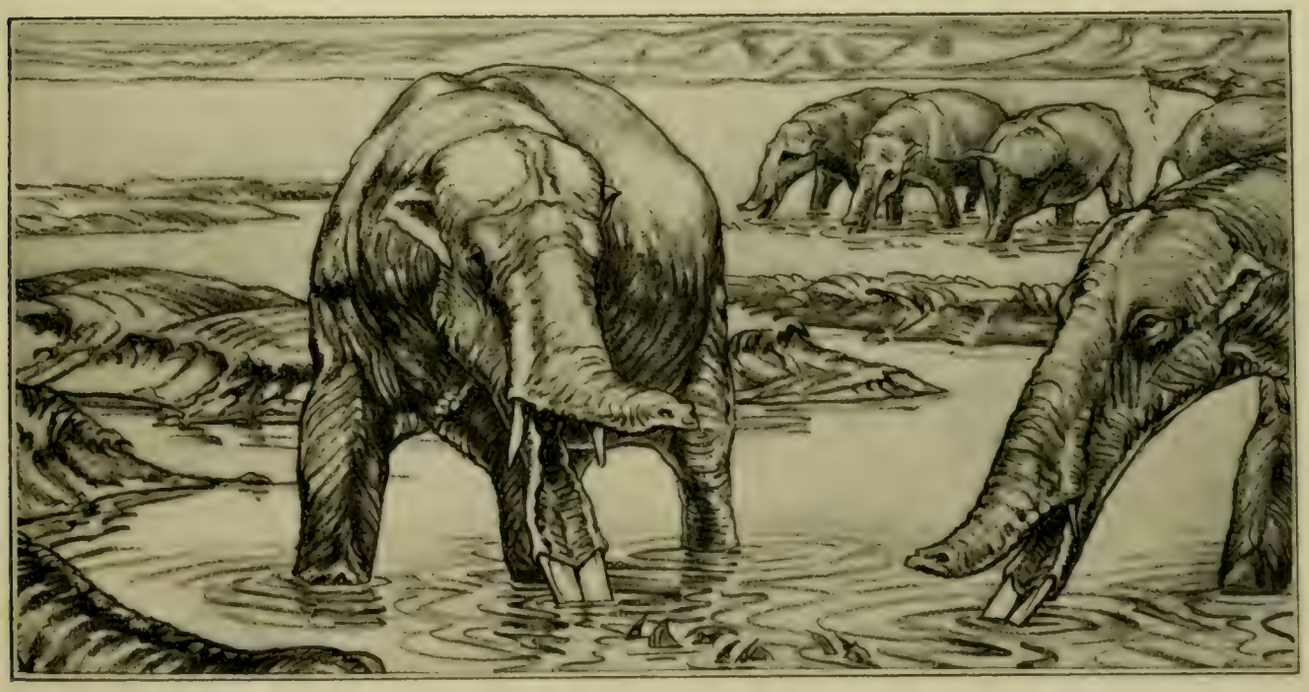


PLATE VI

(Upper) Restoration of *Phiomia osborni* of the Oligocene of Egypt. One thirty-sixth natural size. By Margret Flinsch, 1932. Compare figure 17, page 45.

(Lower) Restoration of *Amebelodon fricki*, 'shovel-tusker' from the Middle Pliocene of Nebraska. One thirty-sixth natural size. By Margret Flinsch, 1932. Compare figure 284, page 332.

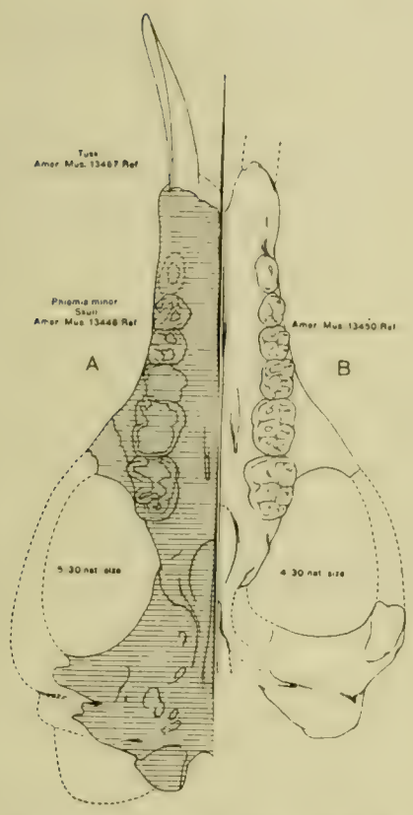


Fig. 178. Palates of the small (A) *Phiomia minor* and of the large (B) *Phiomia wintoni* reduced to the same dental scale, to illustrate differences of facial proportion in these two species: (1) The *cranial* proportions are the same in the two species; (2) the *facial* region is relatively longer (dolichopic) in (B) *Phiomia wintoni* than in (A) *Phiomia minor*.

A, Adult *Phiomia minor* ref. (Amer. Mus. 13448). Five-thirtieths natural size. Associated tusk (Amer. Mus. 13467).

B, Adult *Phiomia wintoni* ref. (Amer. Mus. 13450). Four-thirtieths natural size.

Phylogenetic Characters of Phiomia.—Osborn, 1923: In Osborn's phylogenetic system each genus includes a long series of geologically ascending species and ascending mutations in which certain generic characters are *distinctively progressive*. In a comparison of the above four species, namely, *Phiomia minor*, *P. serridens*, *P. wintoni*, and *P. osborni*, we observe three such progressive generic characters: (1) Progressive dolichodonty, the grinding teeth becoming longer and narrower in proportion; (2) progressive bunomastodonty, the central conules, destined to form trefoils, becoming more prominent; and (3) progressive dolichopy, the facial region elongating more rapidly than the cranial, the latter character being indicated in a comparison of the jaws. The successive stages in generic evolution are all tending towards the typical 'shovel-tusker' *Amebelodon fricki* of the American Pliocene.

Progressive Dolichodonty.—The detailed comparative measurements by the author, assisted by Dr. Charles C. Mook, of twenty-four specimens referable to the three species of *Phiomia* in the British, Cairo, and American Museums more than confirm the statement of Matsumoto that the grinding teeth of *Phiomia* are relatively long and narrow as compared with those of *Palæomastodon*. These relative proportions reach the narrowest extreme in the largest and most progressive species *Phiomia osborni*, index 54, as shown in the accompanying table:

Typical and Average Measurements (in Millimeters) and Indices in Phiomia	M 1-M 3	M 1			M 2			M 3			P 3-M 3
Lower Molars		ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	
Phiomia osborni type (Amer. Mus. 13468)	M_1-M_3 = 172	41	26	63	63	35	56	71	38	54	P_3-M_3 = 246
Phiomia wintoni averages	M_1-M_3 = 166	41	28	68	56	35	62	70	39	56	P_3-M_3 = 236c
Phiomia minor averages	M_1-M_3 = 145	34	23	68	47	30	64	55	35	63	P_3-M_3 = 201
Upper Molars											
Phiomia osborni (not known)											
Phiomia wintoni averages	M^1-M^3 = 162	41	33	80	57	41	72	61	44	72	P^3-M^3 = 214
Phiomia minor (Amer. Mus. 13455)	M^1-M^3 = 129c	33.5	27	81	46	37	80	50	37	74	P^3-M^3 = 185

Progressive narrowing of M_3, prophetic of *Amebelodon fricki* (Pl. v), is seen in a comparison of the indices of the lower molars, as given in the table above, also as follows:

Phiomia osborni, type indices (Amer. Mus. 13468), M_1: 63 M_2: 56 M_3: 54 (relatively narrow)
Phiomia wintoni, ref. " (Amer. Mus. 13476), M_1: 67 M_2: 57 M_3: 56
Phiomia minor type " (Brit. Mus. 8479b), M_1: 66 M_2: 64 M_3: 60 (relatively broad)

According to these extremes the progressive narrowing affects the anterior molars, M_{1-2}, as well as the posterior molar, M_3. The narrow indices of all *Phiomia* teeth, however, are in wide contrast to the relatively broad indices in the corresponding teeth of *Palæomastodon*, as follows:

Phiomia wintoni, average indices, M_1: 68 M_2: 62 M_3: 56 = narrower form; average 55.5. M^3 average 74.
Palæomastodon beadnelli, type indices, M_1: 77 M_2: 78 M_3: 68 = broader form; average 69. M^3 average 76.

Progressive Bunomastodonty.—A bunoid *conule* arising (Fig. 185 A1) in the center of the valleys between the lophoid crests marks the beginning of the bunomastodont character so distinctive of all the longirostrines. It would appear that these central conules, destined to close up and fill the valleys entirely, arise progressively in the three species; at least they are much more clearly marked in the more progressive *P. osborni* than in *P. wintoni* or *P. minor*. Consequently progressive bunomastodonty is a very distinctive generic as well as phyletic character of *Phiomia;* it tends to place these animals in the direct line of ancestry of *Amebelodon fricki*.

Abundance of Phiomia Remains.—In the Fluvio-marine formation, Lower Oligocene, *Phiomia* is as abundant as *Palæomastodon* is rare, the ratio being about eleven to one, since the greater portion of the specimens referred by Andrews to various species of *Palæomastodon* really belong to various species of *Phiomia*. The relative abundance of the three species of *Phiomia* is indicated by the American Museum collections in which the numbers of important specimens run as follows:

Most progressive, *Phiomia osborni*, 1 specimen, 8 miles west of Quarry A
Intermediate in size, *Phiomia wintoni*, 27 specimens, Quarries A, B, and at large
Intermediate in size, *Phiomia serridens*, 1 specimen [= *P.* (?) *wintoni*]
Small form, *Phiomia minor*, 19 specimens, Quarries A, B, and at large

It would be difficult to give the exact figures from the British and Cairo Museums, but from Andrews' references to the species *P. minor* and *P. wintoni*, we deduce the following:

Phiomia osborni: not recognized by Andrews
Phiomia wintoni: very abundant, the prevailing species
Phiomia minor: rare; 5 specimens in British and Cairo Museums

Similar Savanna Habitat of Phiomia and Trilophodon.—The rarity of *Palæomastodon* is attributable to its belonging to the forest-living mastodonts; the abundance of *Phiomia* is attributable to its having a flood-plain habitat similar to that of *Trilophodon* and of other longirostrines which are by far the most abundant proboscideans throughout Oligocene, Miocene, and Lower Pliocene times. Our inference is that *Phiomia* avoided the close forests and lived in a flood-plain and low savanna country, partly open, partly forested, subject to flooding along the river borders. This theory is fully treated in Chapter II on the "Origin and Classification of the Proboscidea."

DISTINCTIONS BETWEEN THE THREE SPECIES

Matsumoto's Definition.—(Matsumoto, 1924.1, p. 14) With slight verbal changes (Osborn's terminology) Matsumoto's definition of the three species in ascending order is as follows:

(1) Posterior end of mandibular symphysis situated a little anterior to P_3; in M_{1-2}, tritolophid distinctly feebler than protolophid and metalophid; M_3 not very long and narrow, trilophodont, the posterior talon being not very prominent; length of lower molar series measuring 126 (Andrews' type)—147 (Amer. Mus. 13471) mm.; that of lower premolar and molar series, 180 (Andrews' type) –202 (Amer. Mus. 13471) mm.; that of upper molar series, 125–130 mm. (Amer. Mus. 13455, 13448); that of upper premolar and molar series, 205–215 mm. (Amer. Mus. 13455, 13448) [no median conules; lower grinders relatively broad]..... *Phiomia minor.*

(2) Mandibular symphysis and lower molars similar to those of *Phiomia minor* except in size; length of lower molar series, 160 (Amer. Mus. 13474)—173 (Andrews) mm.; that of lower premolar and molar series, 225–

250 mm. (Amer. Mus. 13474, 13477); that of upper molar series, 145–170 mm. (Andrews); that of upper premolar and molar series, 255–284 mm. (Amer. Mus. 13474, 13477) [inferior median conules]..... *Phiomia wintoni.*

(3) Posterior end of mandibular symphysis situated a little posterior to the anterior end of P_3; in M_{1-2} the third ridge almost as well developed as the first and second, the widest part of the tooth corresponding to the third ridge; M_3 exceedingly long and narrow, nearly tetralophodont, the tetartolophid corresponding to the prominently developed posterior talon; length of lower molar series, 177-180 mm.; that of lower premolar and molar series, 250–255 mm. (type, Amer. Mus. 13468) [prominent median conules; lower grinders relatively narrow].

Phiomia osborni.

Phiomia minor Andrews, 1904

For original description and type figure, see pp. 58, 59. Also Pl. v

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

This small and less abundant animal, inferior in size both to *Phiomia serridens* and *P. wintoni* and greatly inferior in size to *P. osborni*, was clearly defined by Andrews in his two descriptions as *Palæomastodon minor*, as shown in the systematic revision, Chapter II, above. Matsumoto confirmed this species by referring to it nineteen specimens in the American Museum collection, the dental measurements of seven of which are shown in the above table.

The detailed measurements of three mandibles are cited from Matsumoto in Chapter II, p. 59.

Osborn, 1923: (1) Osborn reviews all the American Museum 1907 collection and confirms all the references by Matsumoto, with the exception of the jaw (Amer. Mus. 13471) which he refers to *Phiomia wintoni*. (2) In the description in the present Memoir of the Fayûm collection, Osborn adds original drawings of *Phiomia* made under his direction also his own observations and comparative measurements of *Phiomia minor*, *P. wintoni*, and *P. osborni*. (3) Osborn differs from the final opinion of Andrews that *Phiomia*

Measurements (in Millimeters) and Indices of Phiomia minor in the British and American Museums	P 4			M 1			M 2			M 3		
Phiomia minor												
Lower Molars				ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.
P. minor type, B.M. M.8479b				32	21	66	45	29	64	48	29	60
P. wintoni ref., A.M. 13471, r.M_1-M_3 = 147				33	26	79	47	32	69	64	38	59
P. wintoni ref., A.M. 13471, l.P_3-M_3 = 202				33	24	73	49	31	74	65	38	58
P. minor ref., A.M. 13469, l.M_1-M_2 = 79				33	21	64	46	30	65			
P. minor ref., A.M. 13469, r.M_1-M_2 = 83				35	25	71	48	31	65			
P. minor ref., A.M. 13475, r.M_1-M_2 = ?				38	24	63	48	28	58			
P. minor ref., A.M. 13483, r.M_2-M_3 = ?							46	31	67	55	32	58
Average meas. and indices 6 of M_1, 8 of M_2, 4 of M_3				34.1	23.3	68	47.3	30.2	63+	54.7	34.7	63+
Upper Molars												
P. minor ref., A.M. 13455, l.M^1-M^3 = 129e				33.5	27	81	43	35.5	83	46	38	83
P. minor ref., A.M. 13448, l.M^1-M^3 = 128	27	32	111	29	33	114	48	37	77	53	40	75
P. minor ref., A.M. 13448, r.M^1-M^3 = 127	28	27	97	28	37	132	47	38	81	53	41	77
Average meas. and indices 3 of M^1, 3 of M^2, 5 of M^3				30.3	32.3	107	45.6	36.8	80	50	36.8	73+

Comparing the above measurements of the upper and lower molars with those on page 237, we observe that the average indices of the first two inferior molars, M_{1-2}, of *P. minor* are closely similar to the average indices of the same teeth in *P. wintoni;* in other words, the proportions of M_1 and M_2 in these two species are the same. In M_3 the case is different. This tooth is much broader in *P. minor* (index 60) than it is in *P. wintoni* (index 56), or in *P. osborni* (index 54). Consequently we are justified in the inference that the third lower molar is progressively narrowing (dolichodonty) as we ascend from *P. minor* to *P. wintoni*, to *P. osborni*.

serridens probably represents a juvenile individual of the same species as *P. minor*, and considers that *P. serridens* more probably belongs to *P. wintoni*.

Phiomia serridens Andrews and Beadnell, 1902

For original description and type figure, see pp. 55, 56

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

Osborn (1924) observes that the juvenile genotype jaw of *Phiomia serridens* Andrews and Beadnell belongs to a species probably, but not certainly, identical with *Palæomastodon* (= *Phiomia*)

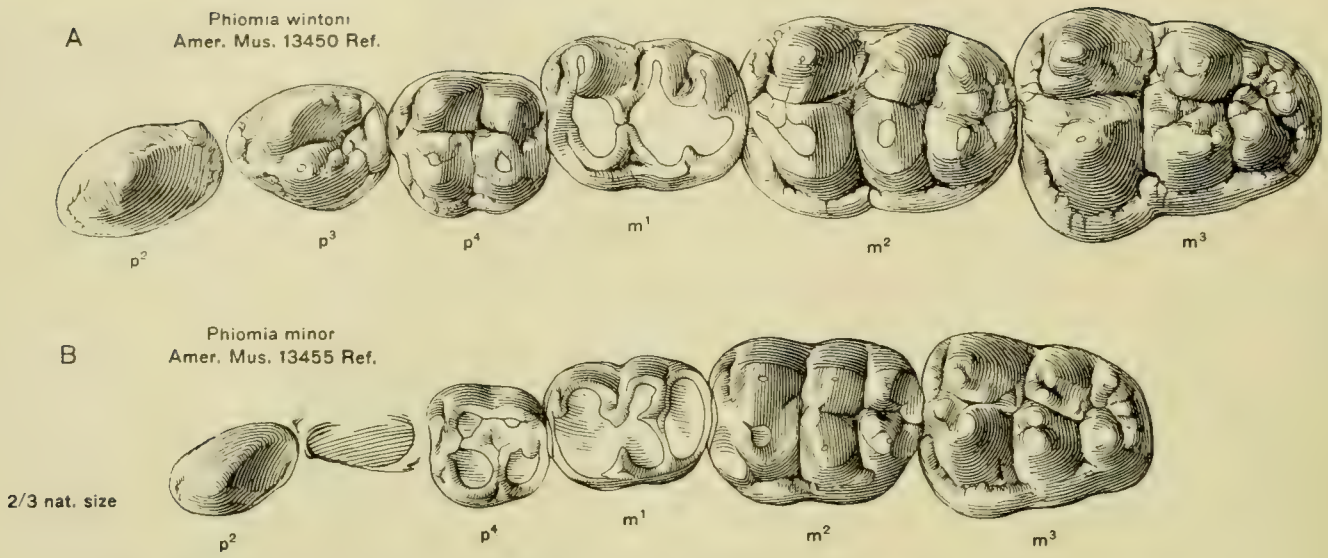


Fig. 179. Superior dentition of the small (B) *Phiomia minor* and of the large (A) *Phiomia wintoni*, two-thirds natural size.
A, *Phiomia wintoni* (Amer. Mus. 13450), referred by Matsumoto, 1922, p. 3, to *Phiomia wintoni*.
B, *Phiomia minor* (Amer. Mus. 13455), referred by Matsumoto, 1922, p. 3, to *Phiomia minor*.

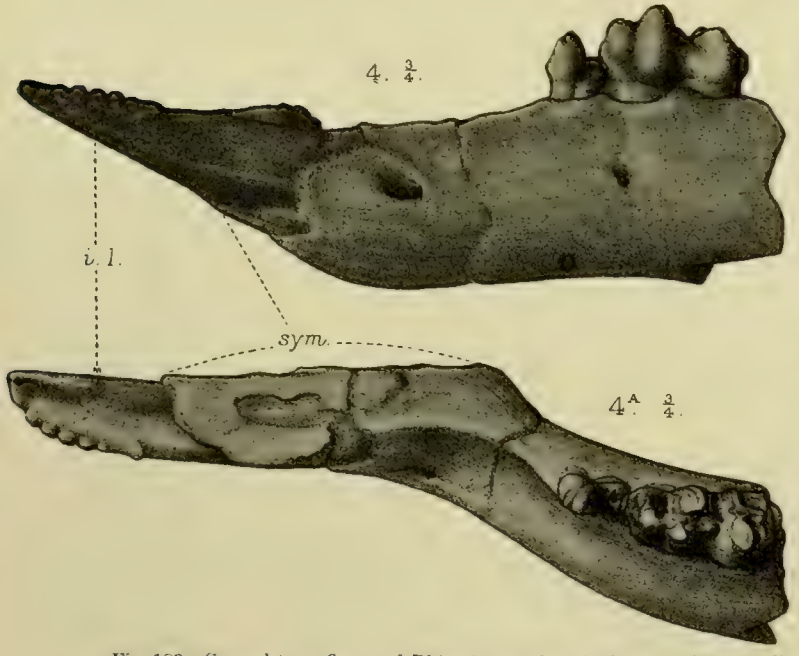


Fig. 180. Second type figure of *Phiomia serridens* Andrews and Beadnell, 1902. After Andrews, 1906, Pl. XVIII, fig. 4: "*Phiomia serridens* Andrews & Beadnell; anterior portion of left ramus of mandible, side and (4A) upper views: three-fourths nat. size. Same horizon [Fluvio-marine beds (Upper Eocene) = Lower Oligocene of present Memoir]. [Type specimen, C. 10007.] Page 170." Geological Museum, Cairo. Compare similar juvenile incisive dentition of *Platybelodon grangeri* (Fig. 433).

wintoni Andrews, 1905, rather than to the smaller form *Palæomastodon* (= *Phiomia*) *minor* Andrews, 1904.

Historic Notes.—(Andrews, 1906, p. 169): "Known only from an imperfect mandibular ramus, in which the single spatulate incisor is serrated on its outer margin. It was originally suggested that this mandible might represent a very aberrant type of Creodont, but this determination is certainly wrong. Schlosser [Footnote: 'Neues Jahrb. f. Min. Geol. u. Palæont. 1905, vol. i. pt. i. (Referate) p. 157.'] has suggested that the specimen in question is the anterior portion of the mandible of a very young *Palæomastodon*, a supposition which not impossibly may be correct, though since this is by no means certain it seems preferable to keep the genus *Phiomia* for the present and place it in its present position." Matsumoto concludes that while the specific name *P. serridens* antedates both the specific names *P. wintoni* and *P. minor*, he finally (1924.1, pp. 14, 33) inclines to relate it to *P. wintoni*.

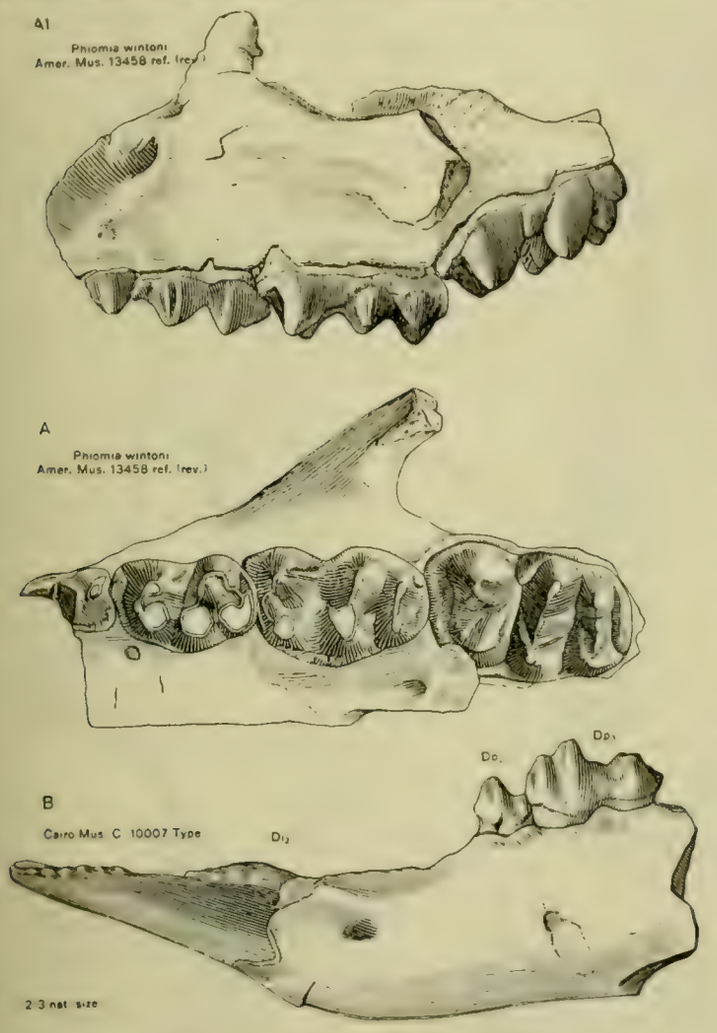
Osborn, 1924: Osborn concludes that the type of *Phiomia serridens* probably belongs to the animal described by all authors as *P. wintoni*, but does not think it wise at present to regard *P. wintoni* as a synonym of *P. serridens*.

JUVENILE MAXILLA A TOPOTYPE OF PHIOMIA SERRIDENS

Specific Resemblance to P. wintoni.—The accompanying figure of the type of *Phiomia serridens* combined with the juvenile maxilla (Amer. Mus. 13458) affords for the first time a more complete knowledge of the juvenile characters of *P. serridens* and proves that it may probably be regarded as belonging to the same animal as certain of the specimens referred to *Phiomia wintoni* in previous descriptions of Andrews and of Matsumoto. From measurements now assembled by Osborn this maxilla may for the present be named *Phiomia wintoni* (cf. *serridens*), at least until the synonymy of these two species is absolutely confirmed (see Fig. 181).

Milk Dentition of Phiomia wintoni (cf. serridens).—The right maxilla (Amer. Mus. 13458) figured below may be associated with the type jaw of *Phiomia serridens* for two reasons: (1) Because Dp^3 agrees exactly in size and relative measurements with the inferior tooth, Dp_3, in the *P. serridens* type; (2) the characters of the milk teeth and first molar, Dp^2-M^1, are exactly what we should anticipate in an ancestor of *Amebelodon;* (3) the first superior molar, M^1, still buried in the jaw, measures ap. 43 mm., tr. 30 mm., index 70; (4) these proportions of M^1, namely, ap. 43 mm., tr. 30 mm., index 70, are extremely close to those of the average *P. wintoni*, namely, ap. 41 mm., tr. 33 mm., index 80, and

greater by far than the largest specimen of *P. minor* (Amer. Mus. 13455) in size and index, namely, ap. 33.5 mm., tr. 27 mm., index 81; (5) M^1 is relatively narrower in ten specimens of *P. wintoni* and relatively broader in eleven specimens of *P. minor*. Consequently we conclude that the juvenile maxilla (Amer. Mus. 13458) certainly belongs to the same animal as that hitherto described as *Phiomia wintoni;* it *probably* belongs to the same specific stage as the type specimen of *Phiomia serridens*.



JUVENILE DENTITION OF PHIOMIA WINTONI (CF. SERRIDENS)

Fig. 181. Fragment of maxilla referred to *Phiomia wintoni* (cf. *serridens*) Andrews. Drawing (reversed) from Amer. Mus. 13458. Two-thirds natural size. From Quarry B, Fayûm, Egypt. Museum Expedition of 1907.

A, A1, Maxilla, crown and lateral views of Dp^2, Dp^3, Dp^4, M^1.

B, Type lower jaw of *Phiomia serridens* Andrews and Beadnell. Original drawing after cast from Cairo Mus. C.10007, containing Di_2, Dp_2, Dp_3; the Dp_3 fits exactly into the Dp^3 of the maxilla.

Juvenile maxilla (Fig. 181 A, A1): Dp^2 partly fractured; Dp^3 tetrabunodont with postero-internal cone; Dp^4 distinctly trilophodont, the protoloph and metaloph broad, the tritoloph narrow; M^1 measurements given above. Dp^3 agrees closely in size and fits precisely into Dp_3 in the *Phiomia serridens* type, as shown in the accompanying illustration.

The literature, however, would become so badly confused if we should make *P. wintoni* a synonym of *P. serridens*, that it seems best to await the final determination of this question through the discovery of more complete material.

MILK DENTITION OF PHIOMIA SERRIDENS TYPE.—(Cf. Andrews, 1906, p. 170) Type jaw: Di_2 with straight inner border, convex outer border marked by about six crenulations, upper face concave, ventral face convex, longitudinal ridges, enamel confined to the end of the crown (enamel entirely wanting in I_2 of *P. wintoni*); diastema 5 cm. in length; Dp_2 small, laterally compressed, high, slightly bifid anterior cusp, small posterior cingular cusp; Dp_3 subtrilophid, convex anterior lobe tricuspid, posterior lobe bicuspid, small posterior tubercle.

Phiomia wintoni Andrews, 1905

For original description and type figure, see pp. 60, 61. Also Pl. v, pp. 235–236

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

Syn.: *Phiomia wintoni* (Andrews, 1905) may prove to be the same animal as *Phiomia serridens* (Andrews and Beadnell, 1902).

This animal, *Phiomia wintoni*, is directly intermediate in size between *P. minor* and *P. osborni*. The detailed measurements of the teeth taken by Matsumoto and by Osborn demonstrate that these three species do not overlap each other; they probably represent three stages of progressive evolution, but this is not yet demonstrated by the geologic records, because *P. minor* and *P. wintoni* occur frequently in the same American Museum quarries (A and B). This may be explained by the theory that the quarry depositions represent long periods of time. This is fully discussed below.

SPECIFIC EVOLUTION.—The relative frequency of the three species in quarries A and B may prove to have some bearing on the question whether *Phiomia minor*, *P. wintoni*, and *P. osborni* are (1) three contemporaneous species in different degrees of evolution; or (2) extremes or variations of sexual difference: or (3) whether each of these quarries represents a very long period of geologic time during which these three specific stages evolved from each other. On the whole, the third supposition is the most probable one.

CHARACTERS OF PHIOMIA WINTONI (MATSUMOTO, 1924.1, PP. 24–40).—(1) Matsumoto and Andrews consider that the type specimen of *Phiomia serridens* belongs to a very juvenile individual probably of *P. wintoni*, or possibly of *P. minor*. (2) Detailed measurements are given of eight jaws of *P. wintoni*, four described by Andrews and four referred by Matsumoto, distinguishing the probable males from the probable females by a slight superiority in size. (3) Detailed measurements are given by Matsumoto of the teeth of eleven specimens, also distinguishing probable males from probable females by superior size. (4) Inferior tusks, e.g., Amer. Mus. 13462, measure 250 mm. in length, 44 mm. anteroposteriorly, 21 mm. transversely; distinction is therefore made between the larger male and smaller female tusks. (5) The principal cranial measurements from four British Museum and four American Museum specimens are given as follows:

Basioccipital length, condyles to premaxillaries: min. 605 mm., max. 700 mm.

Length of palate: min. 350 mm., max. 430 mm.

Width across zygomata: min. 377 mm., max. 447 mm.

Height of skull, basioccipital to sagittal crest: 220 mm.

forty-six specimens referred to *P. wintoni*, in which it is again attempted to distinguish males and females.

Dental Proportions in Phiomia wintoni.—The detailed dental measurements and proportions prove to be of great value, as shown in the probable identification of *Phiomia wintoni* with *P.*

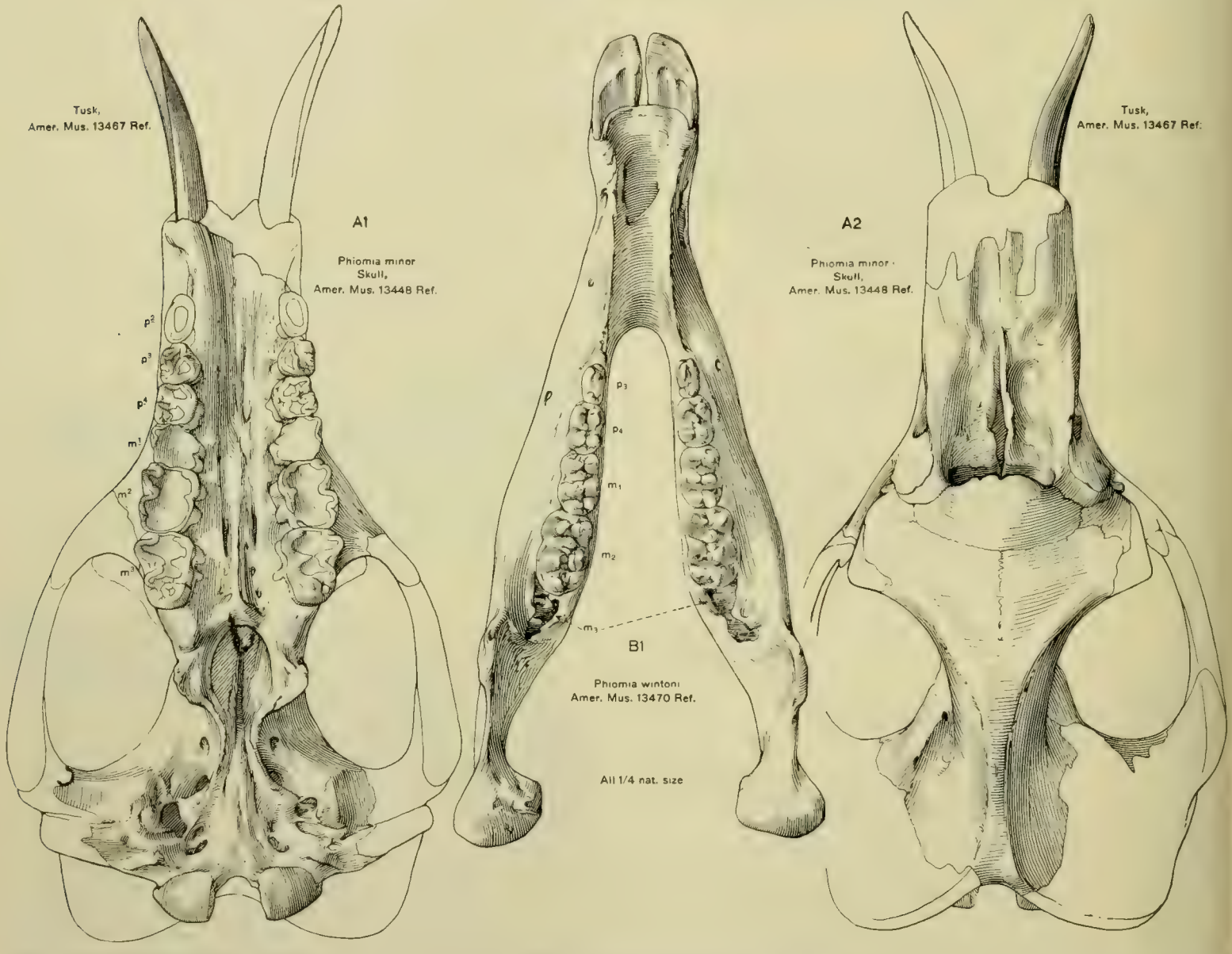


Fig. 182. Referred aged skull of *Phiomia minor* and juvenile jaw of *Phiomia wintoni*. One-fourth natural size.
A1, Palatal view of adult skull of *Phiomia minor*, Amer. Mus. 13448 (referred by Matsumoto, 1922, p. 3, to *P. minor*). Tusk inserted (Amer. Mus. 13467, ref.).
A2, Superior view of same skull, Amer. Mus. 13448.
B1, Referred jaw of *P. wintoni*, Amer. Mus. 13470 (referred by Matsumoto, 1922, p. 3, to *P. wintoni*), M_3 not erupted. Observe *central conules*.

(6) Superior tusks (Amer. Mus. 13466, 13463): Total length 220–250 mm.; anteroposterior diameter 50–44 mm.; transverse diameter 31 28.5 mm. (7) Measurements of one to six of the superior cheek teeth, longitudinally and transversely, are given in *serridens* above. The absolute measurements and dental indices given in the table below, however, indicate that certain specimens properly referable to *Phiomia osborni*, e.g., Cairo Mus. C.8457, may be included in the *Phiomia wintoni* column.

Upper and Lower P. wintoni Molars	M 1-M 3	M 1			M 2			M 3		
Phiomia wintoni										
Lower Molars		ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.
P. wintoni type, B.M. M.8414	M_2-M_3=132				55	35	64	74	44	59
P. wintoni ref., Cairo Mus. C.8456		35	28	80	57	35	61	70	41	58
P. wintoni ref., Cairo Mus. C.8457 (=*P. osborni* ?)		38	25	66	54	31	57	66	35	53
P. wintoni ref., B.M. M.8384		41	28	68	56	33	59	69	40	58
P. wintoni ref., B.M. M.8853		41	28	68	55	35	64	73	41	56
P. wintoni ref., Amer. Mus. 13476	M_1-M_3=166	40	27	67	56	32	57	68	38	56
Average meas. and indices 10 of M_1, 14 of M_2, 12 of M_3		41.6	28	67	56.2	34.9	62	69.7	39	56
Upper Molars										
P. wintoni ref., B.M. M.9450	M^1-M^3=158	42	30	71	57	39	68	61	41	67
P. wintoni ref., Amer. Mus. 13451	M^1-M^3=167	47	35	75	63	45	71	62	48	77
P. wintoni ref., Amer. Mus. 13457	l.M^1-M^3=156	37+	34	92+	56	43	77	59	45	76
Average meas. and indices 8 of M^1, 19 of M^2, 22 of M^3, 5 of M^1-M^3	M^1-M^3=161.6	41	32.7	80	56.7	40.7	72	60.7	44.4	73

Fig 183. Referred aged skull of *Phiomia minor* and juvenile jaw of *Phiomia wintoni*. One-fourth natural size.

Composition drawing: A, *Phiomia minor* skull (Amer. Mus. 13448), tusk (Amer. Mus. 13467); B, *Phiomia wintoni* jaw (Amer. Mus. 13470).

Average Measurements and Indices of Phiomia wintoni

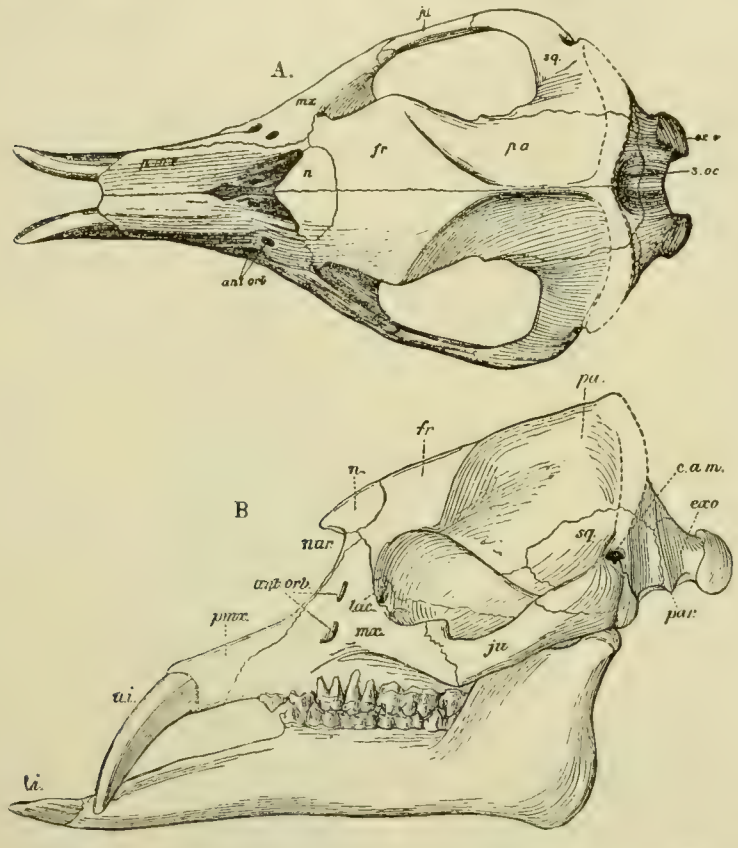
		ap.	tr.	I.		ap.	tr.	I.		ap.	tr.	I.
Superior molars,	M^1,	41	32.7	80	M^2,	56.7	40.7	72	M^3,	60.7	44.4	73
Inferior molars,	M_1,	41.6	28	67	M_2,	56.2	34.9	62	M_3,	69.7	39	56

The average measurements and indices of the upper and lower teeth of *Phiomia wintoni* as contrasted above demonstrate that the inferior molars ($M_{1\text{-}3}$=166 mm.) occupy longer and narrower spaces than the superior molars ($M^{1\text{-}3}$=161.6 mm.).

American Museum Materials.—In connection with the twenty-seven specimens of *Phiomia wintoni* in the American Museum collection determined by Matsumoto, it is interesting to examine the quarry records.

Quarry Records.—From Quarry B [which contains also ten species of *Phiomia minor*] are the following specimens of *P. wintoni*

ref.: Amer. Mus. Nos. 13474, 13476, 13477, 13484, 13494, 13494a, c, d, e, g, 13453, 13454, 13458 (*P. wintoni* cf. *serridens*), 13459, 13479, 13488, 13489, 13491, 13527, 13527b, c, f, g, i, k, m; also superior and inferior tusks, Amer. Mus. Nos. 13462, 13463, 13466c. Quarry A [also containing remains of three specimens of *Phiomia minor*] yields the following numbers: Amer. Mus. 13494b, g, 13451, 13456, 13457, 13492, 13527a, h, j, n; also the tusks, Amer. Mus. 13466a.



ANDREWS' (1906) ERRONEOUS COMBINATION OF THE SKULL OF PHIOMIA WINTONI WITH THE MANDIBLE OF PALÆOMASTODON BEADNELLI

Fig. 184. Andrews' restoration of *Phiomia wintoni* combined with jaw of *Palæomastodon beadnelli*. After Andrews, 1906. This restoration conforms closely to what we now know to be the characters of the skull of *Phiomia wintoni*, although the restoration of the lower jaw (founded on *Palæomastodon beadnelli*) is relatively too long.

First restoration (1906) of the "skull and mandible of *Palæomastodon*" published by Andrews, 1906, p. 131, text fig. 48, A, B. Andrews did not specifically designate the specimen on which his restoration was based, but it would appear to be a combination of four specimens, namely: (a) The type jaw of *Palæomastodon beadnelli* (*op. cit.*, Pl. xv, fig. 1), (b) the symphysis and incisors of *Phiomia wintoni* (*op. cit.*, Pl. xiv, fig. 3), (c) the skull of *Phiomia wintoni* (*op. cit.*, Pl. xii) erroneously referred by Andrews to *Palæomastodon beadnelli*, (d) the anterior portion of a young skull (Pl. xiii).

Osborn, 1923: Andrews' restoration of 1906 is historically interesting as furnishing the basis of our misconceptions of *Palæomastodon* which, as the collections of the American Museum expeditions and the studies of Matsumoto and Osborn have shown, are confused with *Phiomia wintoni*, a typical Amebelodont (Pl. v, pp. 235-236).

Thus Quarry B yielded twenty-nine specimens of *Phiomia wintoni* and ten specimens of *P. minor;* Quarry A yielded eleven specimens of *P. wintoni* and three specimens of *P. minor*.

CRANIAL CHARACTERS OF PHIOMIA WINTONI

(Andrews, letter, 1922): *Referred skull of Phiomia wintoni.* This skull is beautifully figured by Andrews (1906, Pls. xii, xiii, and xiv, fig. 3) and described on the plates under an *erroneous* reference to *Palæomastodon beadnelli* (*?*). This reference was subsequently corrected by Andrews in his own handwriting: . . . "no doubt pl. xii, pl. xiii, pl. xiv, fig. 3, are all *P. wintoni.*" This skull is referred to *Phiomia wintoni* by Matsumoto (1924.1) and by Osborn (present Memoir).

Osborn, 1923: The skull of this species is also important as belonging to the commonest of all the species in the Fluvio-marine beds (=Lower Oligocene). The adult cranium (Pl. xii), together with the anterior portion of a young skull (Pl. xiii) and the type jaw, is obviously the basis of Andrews' semidiagrammatic figure of the skull (*op. cit.*, p. 131, text fig. 48) as here reproduced (Fig. 184).

SPECIFIC CHARACTERS.—Osborn, 1923: (1) Osborn reviews and confirms Matsumoto's observations on the fifty-five specimens in the American Museum 1907 collection referred to *P. wintoni*, adding one jaw (Amer. Mus. 13471) which Matsumoto referred to *P. minor*; (2) he confirms Matsumoto's observations, compares, describes, and figures the best specimens, clearly distinguishing the *P. wintoni* stage of evolution from that of *P. minor* and of *P. osborni*, (3) adds new drawings and tables of comparative measurements made under his direction with the new definition of *Phiomia wintoni*, and (4) gives additional evidence from the detailed evolution of the *P. wintoni* grinding teeth that this species is directly ancestral to *Phiomia osborni* [and (1935) to *Amebelodon fricki*].

Phiomia osborni Matsumoto, 1922

For original description and type figure, see pp. 64, 65. Also Pls. v and vi

Fluvio-marine formation of the Fayûm, Egypt = Upper Eocene of Andrews = Lower Oligocene of the present Memoir.

This animal, represented by a single specimen dedicated to Osborn by Matsumoto, is larger and much more progressive than *Phiomia wintoni* in the tritolophid of the first and second inferior molars, $M_{1\text{-}2}$, and in the tetartolophid of the third inferior molar, M_3. It is also more progressive in the development of the *central conules* (bunomastodonty) arising directly from the floor of the valleys and wearing into characteristic trefoil loops, as shown in the enlarged P_4, M_1 (Fig. 185 A1) taken from the type.

SPECIFIC CHARACTERS.—(Matsumoto, 1922.1, 1924.1). The characters 1 to 11 specified by Matsumoto (1924, pp. 40–49) and cited in full in the systematic revision, Chapter II, pp. 64, 65, are all confirmed by Osborn. The reader is also referred to the condensed definition of this species by Matsumoto in the present chapter, page 236. Osborn (1924) has little to add to the specific characters excepting to refer to the above measurements and dental indices printed in full in the present chapter, page 237, and to give in the table (p. 246) the comparative measurements and indices of *Phiomia osborni*, *Serridentinus serridens*, *S. productus*, and *Trilophodon angustidens*.

PROGRESSIVE DOLICHODONTY.—The average breadth index of M_3 in *Phiomia osborni* (=54) is reduced to 42.7 in *Trilophodon angustidens; Serridentinus productus* is intermediate. It will be observed that the index of M_2 in *S. productus* (=60e) exceeds that of *P. osborni* (=56), whereas in *T. angustidens* it is relatively broader, average 65.7.

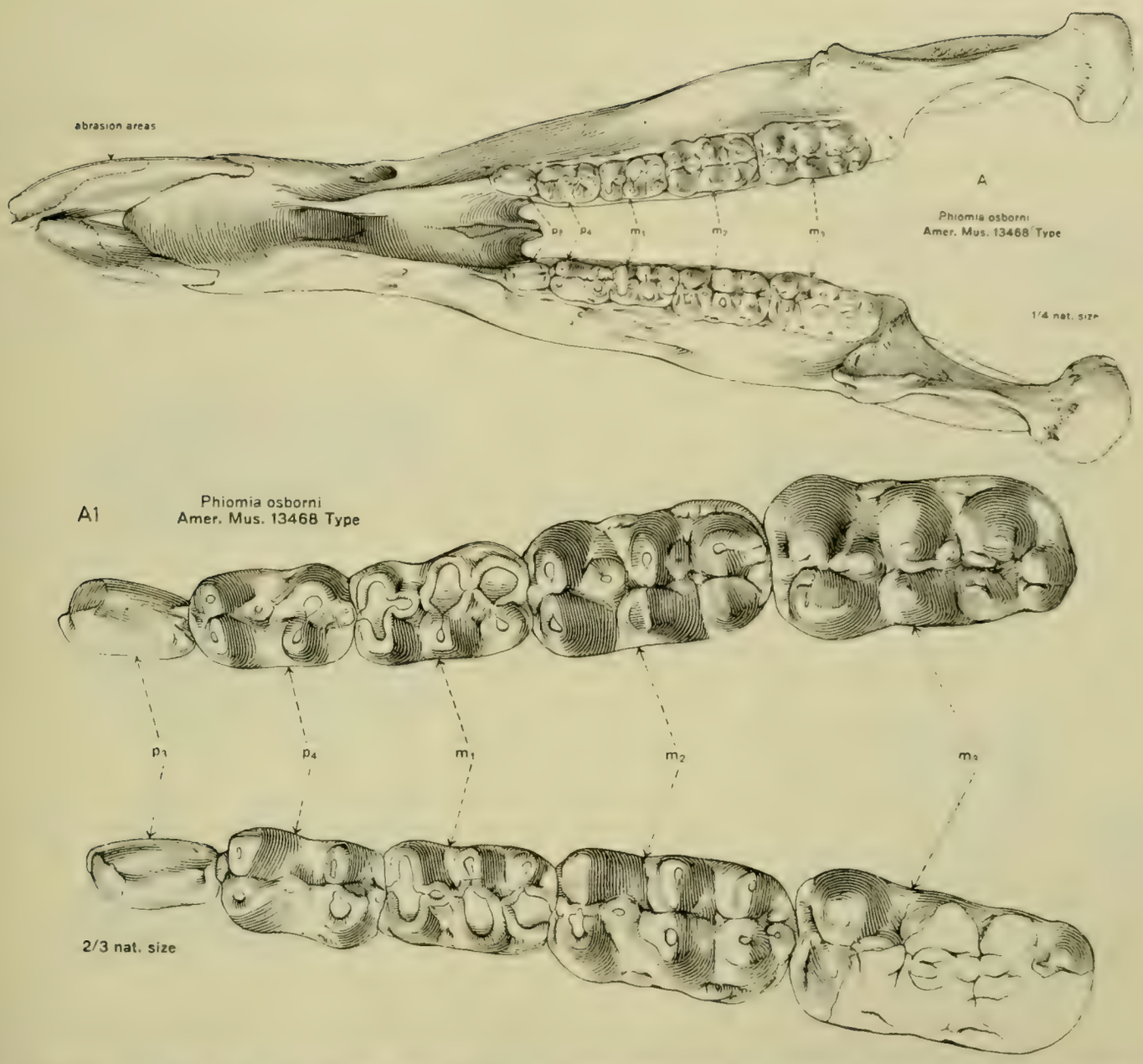


Fig. 185. Second type figure of *Phiomia osborni* Matsumoto, Amer. Mus. 13468 (see Matsumoto, 1922, p. 4, fig. 3, for original type figure—Fig. 40 of the present Memoir). Observe *central conules* in P_4-M_3; for detailed structure of r.M_3, see figure 187B, p. 247, below.

A, (Matsumoto, *op. cit.*, p. 3): . . . "a nearly complete mandible, bearing all the teeth *in situ*." One-fourth natural size. Observe especially the superior view of the paired incisors showing abrasion areas apparently caused by prehensile pressure of the upper lip against these teeth. This specimen, first confused with *Palæomastodon wintoni*, was selected by Matsumoto (1922) as the type of the more progressive species *Phiomia osborni*. A1, Dentition, P_3-M_3, two-thirds natural size, of *P. osborni*. Same type figure as A.

Fig. 185a. Restorations of the five species of *Phiomia* in ascending geologic order, one-hundredth natural size, by Margret Flinsch, under the direction of Henry Fairfield Osborn.

Phiomia, Serridentinus, and Trilophodon Comparative Measurements (in Millimeters) and Indices of Lower Molars		P_4			M_1			M_2			M_3		
		ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.
P. osborni type, A.M. 13468	l.M_1-M_3=172 l. P_3-M_3=246	42	27	64	41	26	63	63	35	56	71	38	54
S. serridens ref., A. M. 10673	P_4-M_2=290	57	43	75	92	62	67	139	69	50			
S. productus ref., A. M. 10582								124e	75	60e	163	76	47
T. angustidens ref., *Simorre*								84	55	66	131.5	59	45
T. angustidens ref., *Simorre*								89	58	65	145	59	41
T. angustidens ref., *Simorre*								93	63.3	68	160	68	43
T. angustidens ref., Tournan								94	60	64	160.4	68	42
T. angustidens ref., Sansan											152	70	46
T. angustidens ref., Sansan											181	78	43
Mounted skeleton								105			176	68	39

The above comparative measurements and indices of the third inferior molar in *Phiomia osborni* (Lower Oligocene), in *Serridentinus productus* (Lower Pliocene of Texas), in *Trilophodon angustidens* from the type locality of Simorre and from the somewhat older Sansan beds, demonstrate the proportional relations of *P. osborni* to the extremely long-jawed or hyperlongirostral *T. angustidens*; also progressive narrowing of M_3.

Condensing the dental indices of these three species in ascending geologic order, we observe the following:

		ap.	tr.	I.		ap.	tr.	I.
Trilophodon angustidens, proportions of	M_2	94	60	64	M_3	160.4	68	42
Serridentinus productus	M_2	124e	75	60e	M_3	163	76	47
Phiomia osborni	M_2	63	35	56	M_3	71	38	54

Dental Adaptation.—The two new figures of the type jaw of *Phiomia osborni* prepared for this Memoir (Figs. 90, 185) illustrate very clearly the adaptation of the pair of closely applied procumbent incisors and of the five parallel grinding teeth, also of the greatly elongated symphysis in contrast to the shorter structure of the jaw in *Palæomastodon beadnelli*. First we observe the *abrasion areas* on the upper surface of the incisors which demonstrate that the upper lip pressed against these teeth in the prehension of food, wearing off the outer surface of the dentine, because the *enamel does not* persist on these teeth. At the extremity of the right incisor, r. I_2, is a worn groove which demonstrates that these teeth were used like a trowel in uprooting plants. To accommodate these greatly enlarged spatulate incisors, which functioned like a broad shovel,[1] the symphysis is increasingly elongated backwards until it reaches the space between r. P_3 and l. P_3, whereas in *P. beadnelli*, an animal of the same size, the symphysis does not extend far backwards.

5. TRANSITION FROM PHIOMIA OSBORNI TO PHIOMIA PYGMÆUS (COMPARE PAGES 276, 277)

Phiomia pygmæus Depéret, 1897

Figures 186, 187

Cartennien de Kabylie, Algeria, near Isserville. Upper (?) Oligocene.

Mastodon angustidens Cuv. mut. asc. *pygmæus* Depéret, 1897. "Découverte du *Mastodon angustidens* dans l'Étage Cartennien de Kabylie," Bull. Soc. géol. de France, (3), XXV, pp. 518–521. Type.—Third inferior molar, M_3 (cast Amer. Mus. 17728). Horizon and Locality.—Near Isserville (Kabylie), Algeria. Étage Cartennien. Type Figure.— *Op. cit.*, Pl. xix, figs. 1, 2, 3.

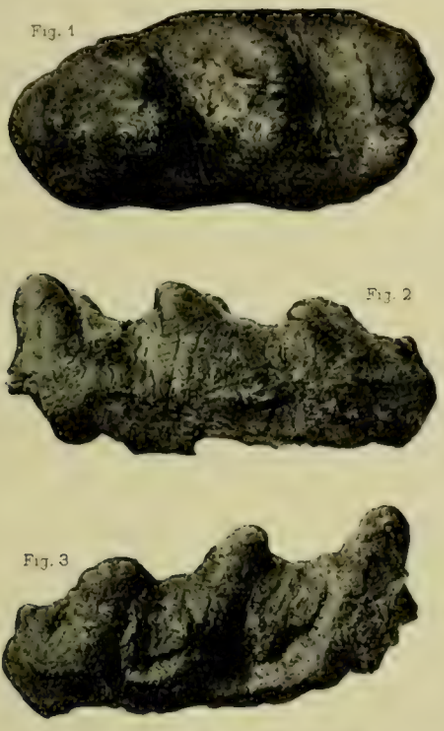
Type Description.—"La molaire en question (pl. xix) n'est pas entière; elle est brisée en avant, et de ce côté il manque une rangée de mamelons; de sorte que la couronne compte seulement trois collines, plus un talon bien prononcé. L'étroitesse générale de la couronne et la forme du talon étroit, triangulaire et pourvu seulement de deux tubercules, indiquent qu'il s'agit d'une molaire inférieure et fort probablement d'une dernière ou sixième molaire, en raison de la grandeur du talon. Chacune des trois collines se compose de deux gros mamelons principaux, arrondis, coniques, assez étroitement accolés l'un à l'autre, mais qui ont une tendance à se dédoubler en dedans sous forme d'un mamelon accessoire moins élevé que le mamelon principal. Les vallées qui séparent les diverses collines sont remplies d'une épaisse masse de cément du sein duquel on voit émerger à peine les mamelons d'émail, qui, en raison de la jeunesse du sujet, n'étaient pas encore entamés par la détrition [*op. cit.*, p. 519]."

COMPARISON WITH PALÆOMASTODON AND PHIOMIA

Osborn, greatly profiting by the rich Fayûm collection in the American Museum, makes a very close comparison of Depéret's type of '*Mastodon*' *angustidens pygmæus* with the corresponding third lower molar of *Phiomia osborni* type (Amer. Mus. 13468) and a characteristic third lower grinder referred to *Palæomastodon beadnelli* (Amer. Mus. 13481), as very carefully illustrated in figure 187 A, B, C.

[1]This passage was written by Osborn two years before the discovery by Barbour of the Nebraska 'shovel-tusker' *Amebelodon fricki*, which proves to be a direct successor to *Phiomia osborni*. See Plates v and vi, also Appendix at the close of the present Volume for the revised Amebelodontinæ.

The type of *Phiomia pygmæus* (original type figure 186, new type figure 187 A–A4) appears to resemble quite closely the type of *Phiomia osborni* and to differ widely from the type and referred specimens of *Palæomastodon beadnelli*. Consequently Osborn removes this species from the genus *Mastodon* and from the subfamily Mastodontinæ and places it in an intermediate position between *Phiomia osborni* and *Trilophodon angustidens*.[1] It may be observed that in *P. pygmæus*, as in *P. osborni*: (1) The summits of the cones are closely compressed towards the central apices of the respective lophs; (2) the summits of the cones are sharply divided into 'conelets,' a pair on either cone, (3) in contrast with *Palæomastodon beadnelli* in which the summits of the cones are widely separated;



TYPE OF PHIOMIA PYGMÆUS

Fig. 186. Type of *Mastodon angustidens* Cuv. mut. asc. *pygmæus* Depéret, 1897, two-thirds natural size. (Depéret, 1897, Pl. XIX, figs. 1–3, p. 521): "Dernière molaire inférieure (brisée en avant) de *Mastodon angustidens* Cuv. mut. asc. *pygmæus* Dep. du Cartennien de Kabylie; vue par dessus (1) et par les côtés interne (2) et externe (3).—Grandeur naturelle." Compare figure 187A (*Phiomia pygmæus*). Cast Amer. Mus. 17728.

(4) the type of *P. pygmæus* also has the elongate, narrow proportions of *P. osborni* and of *Trilophodon angustidens*, rather than the broader proportions of the grinder in *Palæomastodon* and *Mastodon;* (5) the beginning of the tetartolophid is indicated in two cones in *P. pygmæus* and *P. osborni*, demonstrating a progression towards the well-developed tetartolophid of *T. angustidens*.

Osborn, 1925: *Conclusion.*[1] From the above observations and figures, we conclude that *Phiomia pygmæus* is an ascending mutation beyond the stage of *P. osborni* in the direction of the much more highly developed stage of *Trilophodon angustidens*, in which the third inferior molars possess not only a complete tetartolophid but a rudiment of a pentalophid.

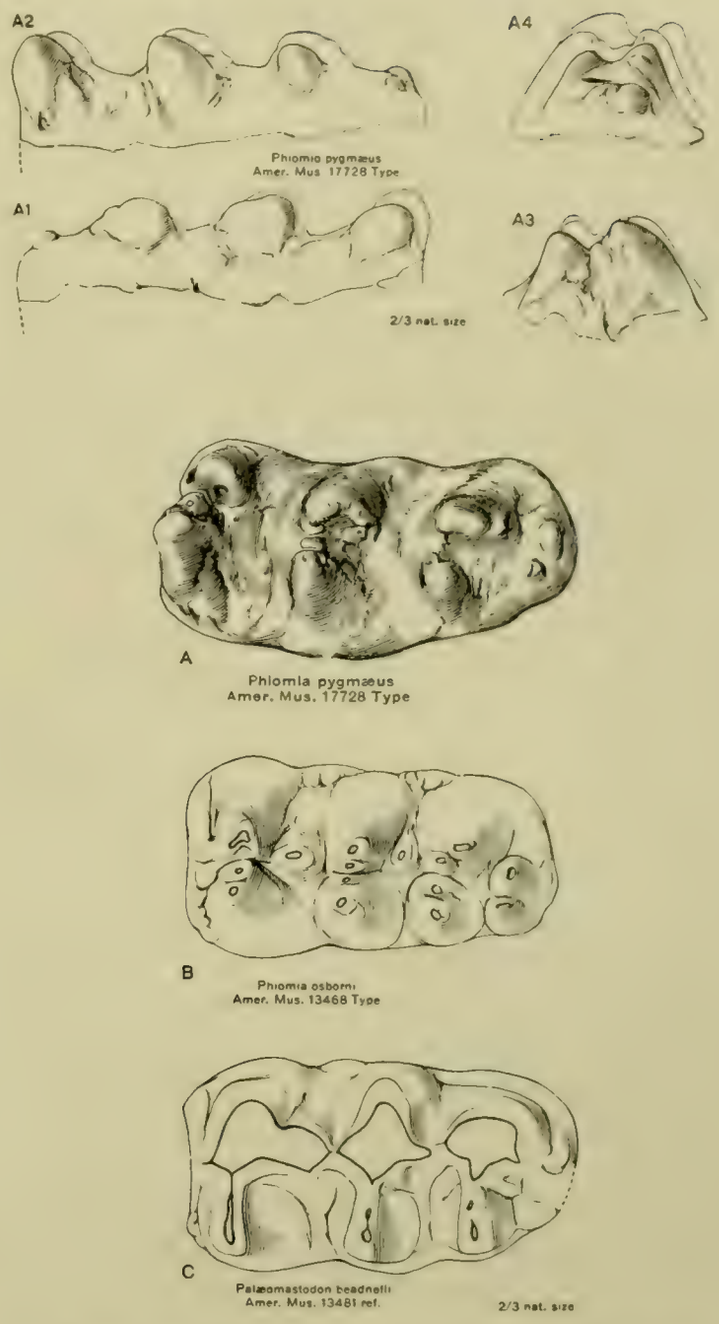


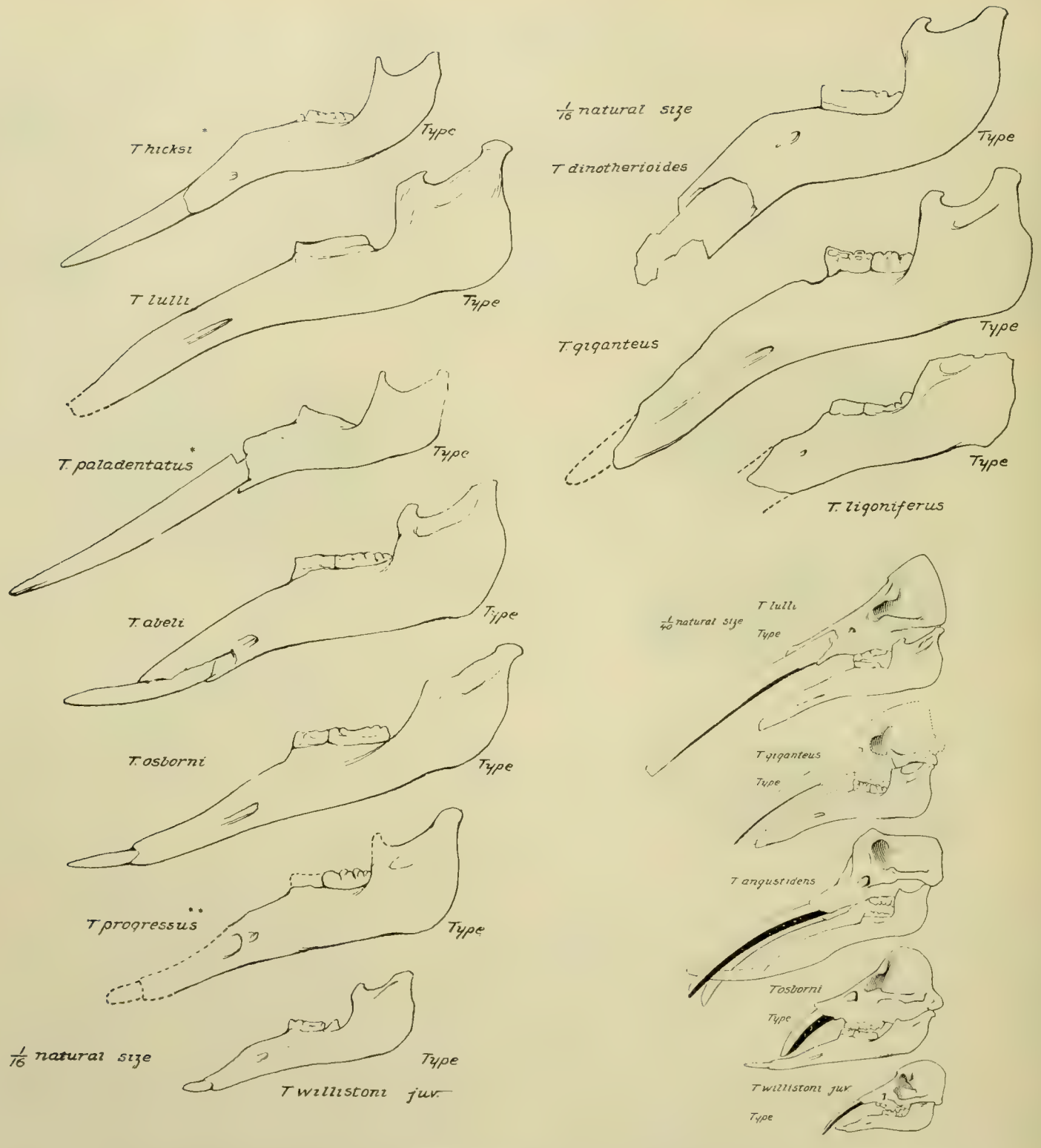
Fig. 187. Comparison of (B) *Phiomia osborni*, (A-A4) type of *Phiomia pygmæus*, and (C) *Palæomastodon beadnelli* third inferior molars. r.M_3, all to the same scale, two-thirds natural size; compare Pl. 1 A, pp. 134–135.

A, A1-A4, original new drawings of Depéret's type of *Mastodon angustidens* Cuv. mut. asc. *pygmæus*, 1897 [=*Phiomia pygmæus* of the present Memoir], after cast of type (Amer. Mus. 17728). (A) crown, (A1) external, (A2) internal, (A3) anterior, and (A4) posterior views. In all four aspects this type is seen to closely resemble (B), the type of *Phiomia osborni*. Compare figure 186, original type figure of *M. angustidens* mut. asc. *pygmæus* Depéret.

B, *Phiomia osborni* type third inferior molar of the right side, r.M_3, crown view. Compare in detail the central conules and conelets of *P. osborni* with those of *P. pygmæus*; observe (B) fourteen conelets in pairs.

C, *Palæomastodon beadnelli* referred third inferior molar, r.M_3 (Amer. Mus. 13481).

[1]The known species of *Phiomia* are regarded by Osborn (1935) as ancestral to the Amebelodontinæ, not to the Longirostrinæ as formerly supposed.



LOWER JAWS AND COMPARATIVE CRANIA OF THE HYPERLONGIROSTRAL TRILOPHODONTS, ALSO OF THE AMEBELODONTS

Fig. 188. Inferior maxillaries in the typical hyperlongirostral *Trilophodon*, all to the same one-sixteenth scale.

Observe the excessively slender mandibular rami of *Trilophodon hicksi*,* *T. lulli*, *T. paladentatus*,* *T. abeli*, *T. osborni*, *T. progressus*,** *T. willistoni* (juv.); the robust, decurved mandibles and laterally flattened incisive tusks of *Trilophodon dinotherioides*, *T. giganteus*, *T. ligoniferus*.

(Right lower). Comparison of crania, one-fortieth natural size, of *Trilophodon lulli*, *T. giganteus*, T. *angustidens* (Paris Museum), *T. osborni*, and *T. willistoni* (Neb. Mus.), especially to illustrate the downward shifting of the enamel band from (1) the lateral posterior position (*T. angustidens*, *T. osborni*, *T. willistoni*) to (2) the inferior position along the lower border of the tusk (*T. giganteus*).

*(1933) = *Amebelodon* (*Trilophodon*) *hicksi*, *A.* (*T.*) *paladentatus*.

**(1933) Referred to *Serridentinus progressus*.

6. HISTORY AND CHARACTERS OF THE GENUS TRILOPHODON FALCONER

SUPERFAMILY: MASTODONTOIDEA Osborn, 1921

FAMILY: BUNOMASTODONTIDÆ Osborn, 1921

SUBFAMILY: LONGIROSTRINÆ Osborn, 1918

GENUS: **TRILOPHODON** Falconer, 1846, 1857

Original reference: "Fauna Antiqua Sivalensis," 1846, Falconer and Cautley (section name, p. 54); also Quart. Journ. Geol. Soc. London, 1857, XIII, pp. 313, 319 (subgenus).

Syn.: *Tetrabelodon* Cope, 1884; compare *Megabelodon* Barbour, 1914 and 1917, *Genomastodon* Barbour, 1917, and *Choerolophodon* Schlesinger, 1917.

GENERIC CHARACTERS. Falconer (1857, p. 316) distinguished *Trilophodon* as follows: "Subgenus 1. *Trilophodon.*—Dentium molarium 3, utrinque intermediorum coronis colliculis 3."

Osborn (1926) observes the following generic characters: Conules in the center of the valleys between the crests (see Figs. 190, 191, 194, 195, 196) as in *Phiomia;* single trefoils arising in the *center* of the valleys; two grinders in use in middle age; distinct in these three characters from *Serridentinus*. Persistent ridge-crest formula P 4-M 2 = $\frac{3}{3}$ M 3 = $\frac{4-4}{4}\ \frac{4}{4}\ \frac{2}{2-3+}$. Central inferior and superior trefoils progressively double.

DEFINITION BY FALCONER, 1846–1857. —The genus *Trilophodon*, originally proposed by Falconer (1846) as a section name (see Chapter I, "2. Revision and Adoption of Generic Names of Proboscidea") and confined by subsequent usage to the genotypic species *Trilophodon angustidens* typical of the Middle Miocene of Simorre, France, proves to be in a high degree *collective*, like the collective genera of Linnæus, because it embraces even within the present Memoir a great range of species extending throughout Miocene time in Europe and a large part of the Miocene, and well into the Pliocene, in America.

HYPERLONGIROSTRINE PHYLUM. It has taken many years to establish the fact that a single generic phylum arose from an unknown ancestor in North Africa and gave rise to the series of long-jawed species in Europe, Asia, and North America, separated from other phyla by constant increment in the following distinctive characters, namely, the long, narrow teeth and the excessively long lower jaw. Typified by *Trilophodon angustidens* of Simorre. Jaws progressively elongating to an extreme; conules arising in the center of the molar valleys to form trefoils; third molars, M^3-M_3, progressively narrowing and elongating, but never exceeding 4 to 4½ to 5+ ridges; first and second molars, $M^{1\text{-}2}M_{1\text{-}2}$, shed relatively early, posterior grinders only, M^3-M_3, functional in extreme old age.

DEFINITION BY OSBORN (1935). —Inferior incisors scaptobelodont, rodlike (*Trilophodon angustidens, T. osborni, T. abeli, T. fricki*), more or less elongate or laterally compressed (*T. dinotherioides, T. giganteus*); sometimes tuskless (*T. phippsi, T. gaillardi, T. lulli*); subcylindrical ('prod-tuskers'); not spatulate or expanded as in the 'shovel-tuskers' (*Amebelodon, Platybelodon, Serbelodon*).

DISCOVERY OF THE GENERIC PHYLUM TRILOPHODON AND ITS BRANCHES

(April, 1935) Our most recent knowledge of the branching (phylogeny) and geologic order of succession will be found in the Appendix of the present Volume I.

The first member of this phylum to be discovered was the Middle Miocene *Mastodon* [*Trilophodon*] *angustidens* Cuvier described in 1817; since then thirty-five species have been described from Africa, India, Japan, Europe, and the United States, exhibiting essentially the same generic characters. This generic hyperlongirostrine phylum arose independently of *Phiomia* in the Fayûm Oligocene, North Africa; it passed through the Lower and Middle Miocene *Trilophodon angustidens* stages of Europe and Asia into the extremely long-jawed American types of the Upper Miocene and the Pliocene of Dakota, Nebraska, Colorado, and New Mexico, to which different generic names have been assigned, such as *Megabelodon* Barbour, 1914, 1917, and *Genomastodon* Barbour, 1917.

KNOWN SPECIES WHICH EXHIBIT THE SAME TENDENCIES OF EVOLUTION AS THE GENOTYPIC SPECIES TRILOPHODON ANGUSTIDENS. ALSO STAGES OF AMEBELODON

PHYLETIC CHARACTERS. The following species are arranged first in chronologic order, then at the close of the present chapter the American species approximately in *descending phylogenetic order*, the most progressive forms being at the top, the most primitive at the bottom. A full list of species which exhibit the same tendencies of evolution as *Trilophodon angustidens* cannot at present be made out, because certain specific types are very incomplete or immature; consequently we may include in the following list those which are certainly related to *T. angustidens*, indicating with an interrogation mark (?) or square brackets [ ] those which are not fully known, also those which are not positively embraced within this phylum. See final polyphyly of *Trilophodon* in Appendix of the present Volume I.

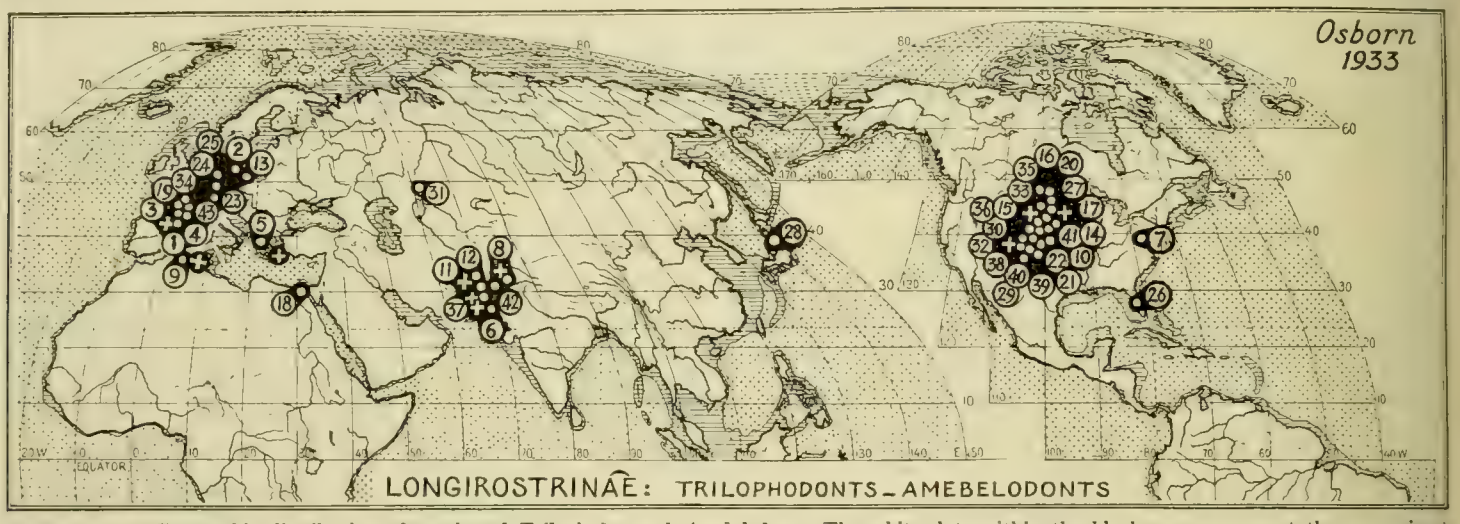


Fig. 189. Geographic distribution of species of *Trilophodon* and *Amebelodon*. The white dots within the black areas represent the approximate localities where the types of these forty-two[1] species were discovered. See figure 24 for map showing the type localities in the Fayûm of Egypt of the various species of *Phiomia*, with the exception of *Phiomia pygmæus* (No. 9 of this map). No. 43 = *Trilophodon pontileviensis*, a duplication (see No. 19). The white crosses represent referred specimens mentioned in the present Memoir.

CHRONOLOGIC ORDER OF DISCOVERY AND PRELIMINARY DESCRIPTION: LONGIROSTRINÆ AND AMEBELODONTINÆ

See Figure 189

			ORIGINAL NAME	SPECIFIC REFERENCE IN PRESENT MEMOIR
1.	1806	Simorre, France	*Mastodonte à dents étroites* Cuvier	= *Trilophodon angustidens*
2.	1806	Saxony	*Petit mastodonte* Cuvier	= *Trilophodon angustidens minutus*
1.	1814	Simorre, France	*Mastotherium leptodon* Fischer de Waldheim	= *Trilophodon angustidens*
1a.	1814	France and Europe	*Mastodon Senodon* Rafinesque	= (?) *Trilophodon angustidens*
1.	1817	Simorre, France	*Mastodon angustidens* Cuvier	= *Trilophodon angustidens*
2.	1818	Saxony	*Mastodon minor* Cuvier (in Desmarest)	= *Trilophodon angustidens minutus*
2.	1824	Saxony	*Mastodon minutus* Cuvier	= *Trilophodon angustidens minutus*
1.	1836	Simorre, France	*M. angustidens minus* Lartet	= *Trilophodon angustidens minutus*
3.	1848	Gers and l'Orléanais, France	*Mastodon Cuvieri* Pomel	= *Trilophodon angustidens cuvieri*
1.	1851	Simorre, France	*Mastodon Simorrense* Lartet	= *Trilophodon angustidens*
4.	1851	Lombez, France	*Mastodon Gaujaci* Lartet	= *Trilophodon angustidens gaujaci*
5.	1856	Pikermi, Greece	*Mastodon pentelicus* Gaudry and Lartet	= *Trilophodon* (*Choerolophodon*) *pentelicus*
6.	1857	Larkana District, Sind, India	*M.* (*Triloph.*) *Pandionis* Falconer	= *Trilophodon pandionis* [cf. *T. palæindicus*]
7.	1869	Near Greensburgh, Caroline County, Maryland	*Mastodon obscurus* Leidy	= *Trilophodon obscurus*
8.	1884	Kamlial, Salt Range, No. Punjab, India	*Mastodon* (*Trilophodon*) *angustidens* Cuv. var. *palæindicus* Lydekker	= *Trilophodon palæindicus* [cf. *T. pandionis*]

[1]Actually forty-one, as *Mastodon angustidens* Cuv. mut. asc. *pygmæus* Depéret (No. 9) equals *Phiomia pygmæus*, and *Torynobelodon loomisi* (No. 35) proves to be a member of the subfamily Platybelodontinæ (see p. 338 below); therefore both appear erroneously on the above map. There should also be included *Anancus* [= *Trilophodon*] *brazosius* Hay, 1923, redetermined by Osborn too late to receive a number and to be inserted on the map. For description and figure, see Chapter IX, page 374, also map (Fig. 307). The Memoir on the "Fossil Proboscidea from China," by Arthur Tindell Hopwood, was not received in time for insertion in this list of his new species *Trilophodon connexus*, *T. wimani*, and *T. spectabilis*. These will be reviewed in the Appendix of the present Volume I.

			Original Name	Specific Reference in Present Memoir
9.	1897	Kabylie, Algeria	*Mastodon angustidens* Cuv. mut. asc. *pygmæus* Depéret	= *Phiomia pygmæus*[1]
	1908	Gaj of Kumbhi, Sind, India	*Tetrabelodon crepusculi* Pilgrim	[*Hemimastodon crepusculi* = Suina]
10.	1909	Northwestern Kansas	*Tetrabelodon dinotherioides* Andrews	= *Trilophodon dinotherioides*
	1912	Gaj of Kumbhi, Sind, India	*Hemimastodon crepusculi* Pilgrim	[*Hemimastodon crepusculi* = Suina]
11.	1913	Lower Chinji, India	*Tetrabelodon angustidens* var. *chinjiensis* Pilgrim	= *Trilophodon chinjiensis*
12.	1913	Upper(?) Chinji, India	*Tetrabelodon macrognathus* Pilgrim	= *Trilophodon macrognathus*
13.	1913	Oppeln, Germany	*Mastodon angustidens* var. *austro-germanica* Wegner	= *Trilophodon angustidens* var. *austro-germanicus*
14.	1914	Devil's Gulch, Nebraska	*Tetrabelodon willistoni* Barbour	= *Trilophodon* (*Genomastodon*) *willistoni*
15.	1914	Snake River, Cherry Co., Neb.	*Tetrabelodon lulli* Barbour	= *Trilophodon* (*Megabelodon*) *lulli*
16.	1915	Black Hills, So. Dakota	*Mastodon ligoniferus* Cope and Matthew	= *Trilophodon ligoniferus*
17.	1916	Bristow, Boyd Co., Nebraska	*Tetrabelodon osborni* Barbour	= *Trilophodon* (*Genomastodon*) *osborni*
18.	1918	Moghara, No. Egypt	*Mastodon angustidens* Cuvier var. *libyca* Fourtau	= *Trilophodon angustidens* var. *libycus*
19.	1918	Faluns Helvétiens du Blésois, France	[*M. angustidens*] mut. *Pontileviensis* Mayet (in Fourtau). Name only	= *Trilophodon pontileviensis* Mayet-Fourtau 1918
20.	1921	Eastview, near Dallas, So. Dakota	*Trilophodon giganteus* Osborn	= *Trilophodon giganteus*
21.	1922	Wray, Yuma Co., Colorado	*Trilophodon hicksi* Cook	= *Amebelodon* (*Trilophodon*) *hicksi*
22.	1922	Wray, Yuma Co., Colorado	*Trilophodon paladentatus* Cook	= *Amebelodon* (*Trilophodon*) *paladentatus*
23.	1922	Engelswies, Germany	*Mastodon engelswiesensis* Klähn	= *Trilophodon engelswiesensis*
24.	1922	Esselborn and Westhofen, Germany	*Mastodon esselbornensis* Klähn	= *Trilophodon esselbornensis*
25.	1922	Steinheim, Germany	*Mastodon steinheimensis* Klähn	= *Trilophodon steinheimensis*
26.	1923	Pierce, Florida	*Serridentinus simplicidens* Osborn	= *Trilophodon simplicidens*
	[1923	Driftwood Creek, Nebraska	*Trilophodon progressus* Osborn	= *Serridentinus progressus*—see Chap. X]
	1923	San Felipe, Texas	*Anancus brazosius* Hay	= *Trilophodon* (?*Tetralophodon*) *brazosius* (see Chap. IX)[1]
27.	1925	Devil's Gulch, Nebraska	*Tetrabelodon abeli* Barbour	= *Trilophodon abeli*
	[1925	Banjôbora, Japan	*Hemimastodon annectens* Matsumoto	= *Serridentinus annectens*—see Chap. X]
28.	1925	Kitayama, Japan	(?)*Trilophodon sendaicus* Matsumoto	= *Trilophodon sendaicus*
29.	1926	Santa Fé marls, New Mexico	*Trilophodon* (*Serridentinus*) *pojoaquensis* Frick	= *Trilophodon pojoaquensis*
30.	1927	Frontier Co., near Freedom, Nebraska	*Amebelodon fricki* Barbour	= *Amebelodon fricki*
31.	1928	Turgai region, Central Asia	*Trilophodon* (*Serridentinus?*) *inopinatus* Borissiak and Bellaeva	= *Trilophodon inopinatus*
32.	1928	Moffat County, Colorado	*Serridentinus fricki* Peterson	= *Trilophodon fricki*
33.	1928	Ainsworth, Nebraska	*Trilophodon phippsi* Cook	= *Trilophodon phippsi*
34.	1929	Villefranche d'Astarac, France	*Trilophodon angustidens gaillardi* Osborn	= *Trilophodon angustidens gaillardi*
	[1929	Tairum Nor Basin, Mongolia	*Amebelodon grangeri* Osborn	= *Platybelodon grangeri*[2]]
35.	1929	Harlan County, Nebraska	*Torynobelodon loomisi* Barbour	= *Amebelodon* (*Torynobelodon*) *loomisi* (=*fricki*)[1]
36.	1930	Frontier County, near Freedom, Nebraska	*Amebelodon sinclairi* Barbour	= *Amebelodon sinclairi*
	[1930	Marl beds of North Carolina	*Gomphotherium? emmonsi* Hay	= *Ocalientinus emmonsi*——see Chap. X]
	[1930	Snake Creek, Nebraska	*Gomphotherium serpentirivale* Hay	= Nomen nudum]
	[1930	Frederick, Oklahoma	*Gomphotherium priestleyi* Hay and Cook	= *Stegomastodon priestleyi*—see Chap. XIII]
37.	1932	Dera Bugti, Baluchistan	*Trilophodon cooperi* Osborn	= *Trilophodon cooperi*
38.	1933	Santa Cruz, New Mexico	*Trilophodon cruziensis* Frick	= *Trilophodon cruziensis*
39.	1933	Battleship Mt., New Mexico	*Tatabelodon riograndensis* Frick	= *Trilophodon* (*Tatabelodon*) *riograndensis*
40.	1933	Santa Cruz, New Mexico	(?) *Amebelodon joraki* Frick	= *Trilophodon joraki*
41.	1933	Ainsworth, Nebraska	*Tatabelodon gregorii* Frick	= *Trilophodon* (*Tatabelodon*) *gregorii*
	[1933	Mohave Desert, Calif.	*Trilophodon barstonis* Frick	= *Serridentinus barstonis*—see Chap. X]
42	1933	Hasnot, India	*Trilophodon hasnotensis* sp. nov.	= *Trilophodon hasnotensis*

[1]See footnote on page 250.

[2]Now removed to the serridentine subfamily Platybelodontinæ (Chap. X).

7. TYPICAL TRILOPHODON ANGUSTIDENS OF CUVIER INCLUDING EUROPEAN AND AFRICAN STAGES. SEPARATION FROM SERRIDENTINUS

The restriction by Osborn of the genus *Trilophodon* to a series of animals leading into the typical Middle Miocene species *Trilophodon angustidens* and into a series of ascending mutations and species migrating eastward into Asia and North America, is a very essential step in the phylogeny of the Proboscidea, because each *palæontologic genus comprises only a single line of ascent and descent*, other lines and side-lines leading into other genera with different generic tendencies. This classic species, the second mastodont to be described, was named "*angustidens*" by Cuvier, because the type molar (Figs. 190, 299) is decidedly *narrower* (i.e., *à dents étroites*) than the corresponding tooth of *Mastodon americanus*.

Cuvier's type and referred molars are further described in the Appendix (pp. 340, 341) of the present chapter; also (p. 283) the Lower Miocene stage *Trilophodon pontileviensis* of the Orléanais of France is described in comparison with *T. cooperi* of the Bugti Hills, Baluchistan.

Trilophodon angustidens Cuvier, 1806, 1817

Figures 78, 190, 299

Type: Middle Miocene, Simorre, France. Referred: Sansan, Tournan.
Syn.: *Mastodonte à dents étroites* Cuvier, 1806; *Petit Mastodonte* Cuvier, 1806; *Mastotherium leptodon* Fischer de Waldheim, 1814; *Mastodon Senodon* Rafinesque, 1814; *Mastodon minor* Cuvier (in Desmarest, 1818); *M. minutus* Cuvier, 1824; *M. cuvieri* Pomel, 1848; *M. simorrense* Lartet, 1851; *M. gaujaci* Lartet, 1851. Compare *M. angustidens pontileviensis* Mayet (in Fourtau, 1918, Osborn, 1932–1933), p. 283.

Mastodonte à dents étroites Cuvier, 1806. "Sur Différentes Dents du Genre des Mastodontes." Ann. Mus. d'Hist. Nat. Paris, VIII, pp. 405, 412.

Mastodon angustidens Cuvier, 1817. "Le Règne Animal," p. 233.

This classic type species of the Middle Miocene of Simorre, France, is at present in a high degree *collective* inasmuch as now labeled in the European museums it embraces all the Miocene stages in Europe, from the Sables de l'Orléanais upwards, and includes probably two distinct phyla, namely, the true hyperlongirostral *Trilophodon angustidens* phylum and a medilongirostral phylum recently distinguished by Osborn and named *Serridentinus;* consequently the numerous specimens in all the museums of western Europe require monographic revision in which the dental indices may be carefully measured and estimated and these two 'collective genera' and the 'collective species' separated.

Type.—Probably a second inferior molar of the right side, r.M_2, cast in Mantell Coll. in British Museum, also cast Amer. Mus. 21921. This type belongs in the Muséum d'Histoire Naturelle, Paris, but could not be located for the writer during his visit of 1921. Horizon and Locality.—Middle Miocene, Simorre, France. Type Figure.—Cuvier, 1806.3, Pl. 66 (I), fig. 4. New type figure 299, page 340.

Referred.—The *seven* referred specimens (Paris Museum) from Simorre, Sansan, and Tournan, of which detailed measurements by Matthew and Frick are printed above and below, give the typical characters and proportions of *T. angustidens* of the Middle Miocene period in France. See also page 340 of present Volume I.

Cuvier's Type of Trilophodon angustidens

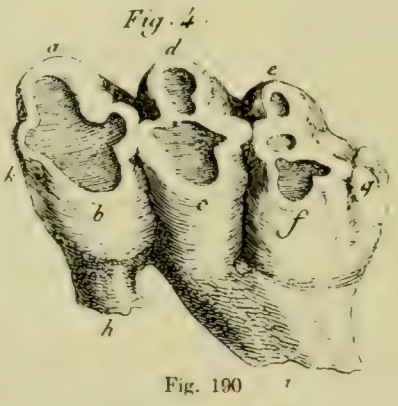


Fig. 190

Cuvier's Type of Trilophodon angustidens minutus

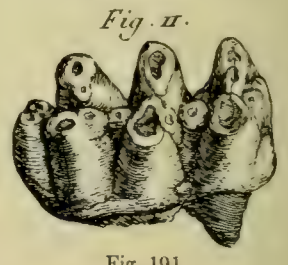


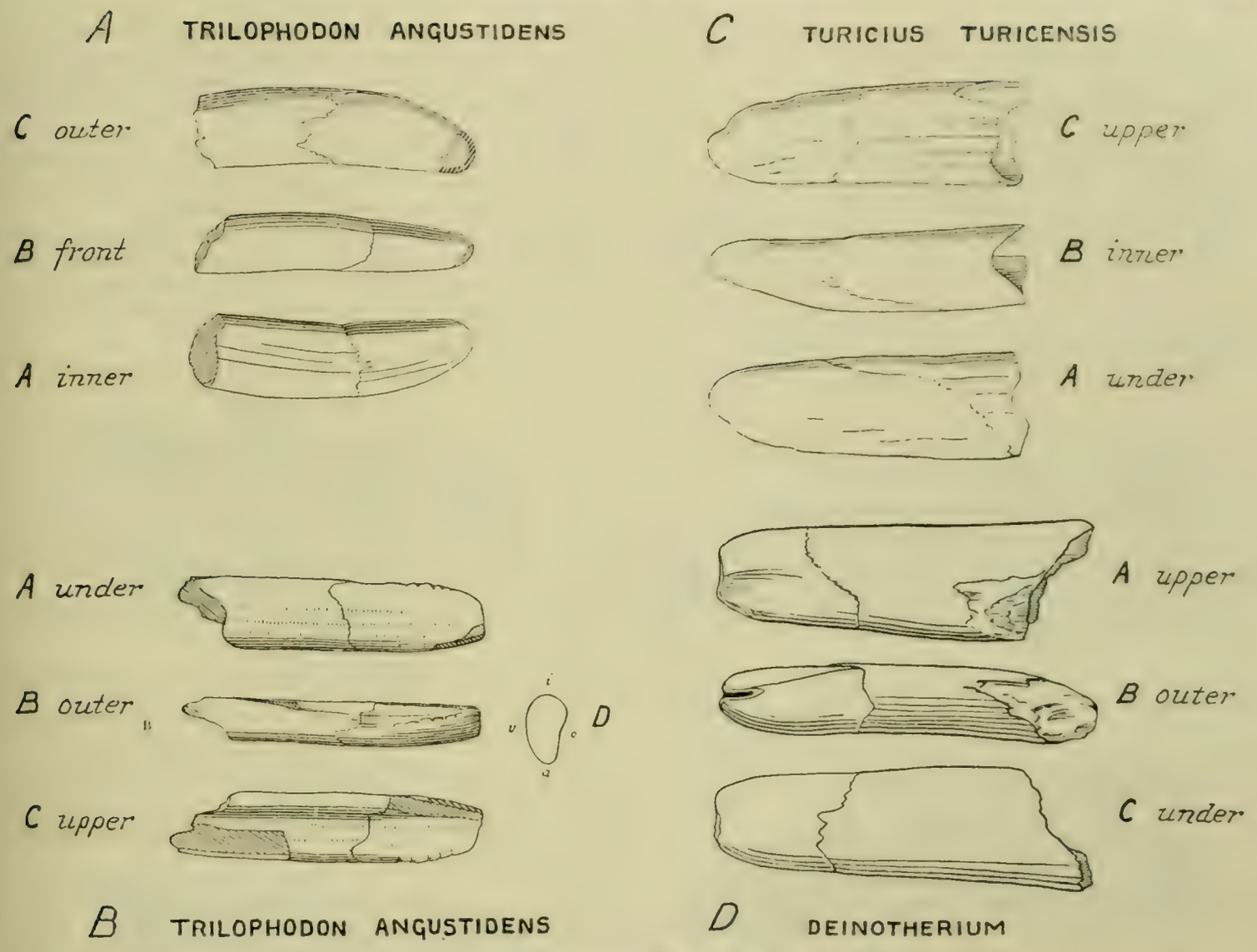
Fig. 191

Fig. 190. Type "*Mastodonte à dents étroites*" Cuv., 1806 = *Mastodon angustidens* Cuv., 1817. Same size as original figure. After Cuvier, 1806.3, Pl. 66 (I), fig. 4. From Simorre, France, Middle Miocene. A second inferior molar of the right side, r.M_2 (cast Amer. Mus. 21921). Unfortunately this figure is drawn in perspective and is inaccurate; the new type figure (Fig. 299) drawn from the type cast gives the true proportions. Paris Mus. A. C. 1842. Observe *central conules* also in *Trilophodon angustidens minutus* (Fig. 191).

Fig. 191. *Petit mastodonte* Cuv , 1806, Pl. 67 (II), fig. 11, from Saxony = *Mastodon minutus* Cuv., 1824 (see Cuvier, 1824, Vol. V, Pt. 2, p. 527). Same size as original figure. Apparently a second inferior molar of the right side, r.M_2.

(Cuvier, 1806.3, p. 411): "Telle est la dent de Saxe, envoyée autrefois par le professeur de Gottingue, *Hugo*, à Bernard *de Jussieu*, et que l'illustre neveu de celui-ci a bien voulu me communiquer, Pl. III [II], fig. 11, entièrement semblable en figure et en proportions à celle de la fig. 4, pl. I. Elle est exactement d'un tiers moindre."

(Cuvier, 1821, Vol. I, p. 268): "Ainsi, indépendamment du grand *mastodonte de l'Ohio*, et du *mastodonte à dents étroites*, espéces aujourd'hui bien connues et parfaitement déterminées, nous trouvons des indices de quatre mastodontes, qui paroissent former d'autres espèces. Les deux qui viennent d'Amérique pourront s'appeler, lorsque leurs caractères seront entièrement confirmés, *mastodonte des cordilières* et *mastodonte humboldien*. Je donnerai au premier de ceux d'Europe le nom de *petit mastodonte*, et au second, dont les collines ne sont pas complétement divisées en mamelons, celui de *mastodonte tapiroïde*".



DECIDUOUS INCISORS, TRILOPHODON, TURICIUS, AND DEINOTHERIUM

Fig. 192. *Trilophodon*, *Turicius*, and *Deinotherium* superior and inferior deciduous incisive tusks. After Stehlin, 1926. Of Lower Miocene, Burdigalian, age.

A, *Trilophodon angustidens* from the Sables de l'Orléanais, a right superior milk incisor, r.Di^2, showing the enamel cap at the extremity. External (C), anterior (B), and internal (A) aspects.

B, *Trilophodon angustidens* from the Sables de l'Orléanais, a right inferior milk incisor, r.Di_2. Inferior (A), external (B), and superior (C) aspects, section (D). This tooth with its corrugated border displays a striking resemblance to the corresponding inferior milk tooth of *Phiomia serridens* (Fig. 180).

C, *Turicius turicensis* from Pontlevoy-Thenay, a right inferior milk incisor, r.Di_2. Observe the wide distinction from *T. angustidens* and approach to the form of the corresponding incisor in *Mastodon americanus*. Superior (C), internal (B), and inferior (A) aspects.

D, *Deinotherium curieri* from the Lower Miocene (Burdigalian) of Pontlevoy-Thenay, a left inferior milk incisor, l.Di_2. Superior (A), external (B), and inferior (C) aspects.

TYPE DESCRIPTION.—(Cuvier, 1806.3, p. 405): "Je commence par une dent de *Simorre*, pl. 1, fig. 4. C'est celle que décrit Daubenton, *Hist. nat.*, XII, n.° 1109. Longue de 0,116, large de 0,06[1] elle est déjà à moitié usée. De ses six paires de pointes, les deux antérieures sont confondues en un disque à quatre lobes, *a*, *b*; une des mitoyennes, *c*, est déjà en trèfle, laissant encore un petit disque rond isolé; l'autre, *d*, est elliptique, bilobée; les dernières, *e*, *f*, n'offrent encore que quatre disques, dont un seulement commence à se lober. On voit qu'un peu plus usée, cette dent auroit eu trois disques à quatre lobes. En arrière, est un talon de deux pointes mousses sillonnées, dont l'une, *g*, est plus haute. Cette couronne est moins usée, et par conséquent plus haute, du côté des disques non lobés, *a*, *d*, *e*, que nous verrons bientôt être l'externe. Deux grosses racines rompues l'une et l'autre se dirigent en arrière; la postérieure, *i*, est de beaucoup la plus grosse: enfin il y a en avant, en *k*, un aplatissement qui fait juger que cette dent étoit précédée par une autre dans la mâchoire."

(CUVIER, 1817, p. 233).—"*Le Mastodonte à dents étroites.* (*Mastodon angustidens.* Cuv. . . .). Dont les mâchelières, plus étroites que celles du précédent, offrent, par la détrition, des disques

[1]See page 340.

en forme de treffles, qui les ont fait confondre par quelques auteurs avec des mâchelières d'hippopotames, était d'un tiers moindre que le grand mastodonte, et bien plus bas sur jambes. On en trouve les dépouilles dans presque toute l'Europe et dans la plus grande partie de l'Amérique méridionale. Dans quelques endroits ses dents, teintes par le fer, deviennent, en les chauffant, d'un assez beau bleu, et donnent ce qu'on appelle des turquoises occidentales."

Topotypes of T. angustidens, Paris Museum.—The lacustrine *Calcaire de Simorre* is important as the *type geologic level* of *M. angustidens* Cuv. The Simorre beds directly overlie those of Sansan and are distinguished by a fauna of a more recent specific stage; for example, the species of rhinoceros, of gibbon, etc., of Simorre are more advanced than those from Sansan, and we should expect, therefore, to find the Trilophodonts also in a more advanced stage. From Simorre are several specimens referred to *T. angustidens* (jaws and teeth); one a remarkably small adult in which M_2 is well worn and M_3 is just coming into wear; the teeth are very little larger than in *Phiomia osborni*. A second specimen of a tooth of *T. angustidens* is slightly more aged and somewhat larger. A pair of superior tusks from Simorre is relatively straight, with a spiral twist, the enamel band very distinct following the concave of the spiral. Other specimens from Simorre and Pontlevoy, which exhibit wide variation in all characters, are also included under the name *T. angustidens*, although they obviously represent more than one species.

Geologic Range.—The geologic range and the referred nomenclature of specimens from different geologic levels and different localities in France are indicated in the following list by Mayet (1909, p. 44). In the meantime it is desirable to establish firmly the characters of the typical form *Trilophodon angustidens* from the upper Middle Miocene of Simorre and of other forms from the underlying Sansan beds which are known to be of earlier geologic age.

Fig. 193. Horizons of the Sables de l'Orléanais, etc., in which primitive species of *Trilophodon, Turicius, Zygolophodon,* and *Deinotherium* first appear in Europe. After Depéret (1905–1908) and Osborn (1910.346, p. 250, fig. 126). Compare figure 189, also Geologic Table in Volume II, Chapter XXII (Geology).

The map below (1910) omits the Lower Miocene and Upper Oligocene of North Africa containing *Phiomia pygmæus, Rhynchotherium spenceri,* and *Trilophodon angustidens* var. *libycus*. Compare figure 143, Chapter VII, Middle and Upper Miocene.

LOWER MIOCENE Burdigalian. FRANCE.—Sables de **1** *Neuville-aux-Bois* (Loiret), fluviatile, sables de *Rebréchien*, **2** *Marigny*, **3** *Fay-aux-Loges*, **4** *Beaugency*, **5** *Tavers*, **6** *Les Barres, Artenay*, marnes du *Blésois*, calcaire de *Montabuzard* (Loiret), lacustrine. Sables de **7** *Chilleurs, Chevilly* (Loiret), **8** *Neuvilly*, near Belgian frontier, fluviatile. Sables de **9** *Ruan*, north central France. Calcaires et marnes de **10** *Suèvres* (Loire-et-Cher). Faluns et calcaires de **11** *Pontlevoy*, faluns et sables de *Thenay*, in la Touraine. Sables de **12** *Chitenay* (Loire-et-Cher), fluviatile. Faluns de **13** *Manthelan*, in la Touraine, marine. **14** *Saint-Nazaire-en-Royans* (Drôme). Mollasse blanche de **15** *Angles* (Gard). LOWER-AUSTRIA.—Mollasse of **16** *Eggenburg*, marine. Marine deposits of **17** *Linz*. SWITZERLAND.—Muschelsandstein von **18** *Brüttelen*, **19** *Macconens, La Molière*, **20** *Bucheggberg*, western Switzerland, marine. PORTUGAL.—Mollasse of **21** *Horta de Tripas*, near Lisbon. GERMANY.—Spalte der Schieferbrüche von **22** *Solenhofen* (Bavaria). Correlation of Depéret.

A. — MASTODONTES A MAMELONS ARRONDIS (TYPE BUNODONTE)

Mastodon angustidens Cuvier.

1825. ***Mastodon angustidens***. Cuvier, *Ossements fossiles*, t. I, p. 250.
1825. ***Mastodon minutus***. Cuvier, *Id.*, p. 267, pl. II, fig. 11.
1851. ***Mastodon Simorrense***. Lartet, *Notice sur la colline de Sansan*, p. 24.
1851. ***Mastodon Gaujaci***. Lartet, *Id.*, p. 24.
1854. ***Mastodon Cuvieri***. Pomel, *Catalogue méthodique*, p. 76.
1859. ***Mastodon angustidens***. Lartet, Note sur la dentition des proboscidiens vivants et fossiles (*Bulletin de la Société géologique de France*, 1859, p. 469, pl. XVI, fig. 1-4; pl. XX, fig. 6).
1859. ***Mastodon angustidens***. P. Gervais, *Zoologie et Paléontologie françaises*, 2e édit.
1870. ***Mastodon arvernensis***. Fraas, *Die Fauna von Steinheim*, Stuttgart, 1870.
1887. ***Mastodon angustidens***. Depéret, Vertébrés miocènes de la vallée du Rhône (*Archives du Muséum d'histoire naturelle de Lyon*, t. IV [1]).
1898. ***Mastodon angustidens***. Mayet, Mammifères miocènes des sables de l'Orléanais et des faluns de la Touraine (*Annales de l'Université de Lyon*, fasc. 24); — des sables de l'Orléanais, p. 140, pl. VII, fig. 3, 4, 5, 6; — des faluns du Blésois, p. 297, pl. XI, fig. 2 et 3).

Species, including types and referred specimens, related to the *Trilophodon angustidens* phylum [=Longirostrinæ]. After Mayet, 1909, p. 44.

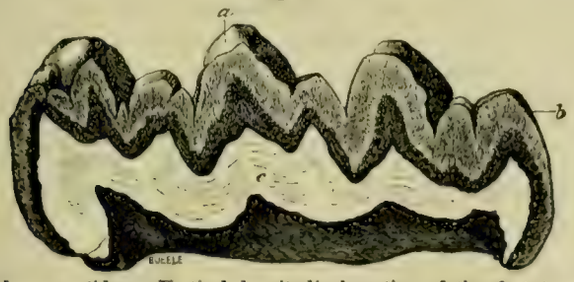
Typical Dental Characters[1] (Osborn, 1923–1925).—(1) The actual type tooth (Fig. 190) which Cuvier selected in 1806 as "*Mastodonte à dents étroites*," as compared with the broader teeth of the American Mastodon, could not be located in the Paris Museum at the time of the author's visit in 1921. Fortunately the type cast (Amer. Mus. 21921) sent by Cuvier to Mantell (Fig. 299), a second inferior molar of the right side, r.M_2, measuring ap. 116 mm., tr. 60 mm., index 52, agrees precisely with Cuvier's type description as cited above; each valley has a *central conule* tending to form an external trefoil; it is narrow in front, broadening behind, namely, protolophid 52 mm., metalophid 60 mm., and tritolophid 64 mm.; the tritolophid is represented by a single cone. The type r.M_2 of *Trilophodon angustidens* is somewhat smaller than Wegner's type r.M_2 of *Mastodon* [=*Trilophodon*] *angustidens* var. *austro-germanicus* (Fig. 201).

(2) The type of the synonymous *Mastodon minutus* Cuv., 1824, from Saxony, is also reproduced (Fig. 191) from Cuvier's figure, clearly showing the *central conules* arising exactly in the center of the valleys as they do in *Phiomia osborni;* it has the proportions of a second inferior molar of the right side, r.M_2,

[1]Compare revised text in Appendix to this chapter (p. 340, fig. 299).

but it is very difficult to determine without examination of the original specimen, which was not accessible to the writer in the Paris Museum; it is relatively too long to be a superior molar. (3) The rise of the *central conules* directly in the center of the valleys is shown (Fig. 194) in a second inferior molar, erroneously determined by Lydekker as a "first lower true molar," from Simorre, cut longitudinally and showing the protolophid, metalophid, tritolophid, and a rudimentary tetartolophid (*b*). (4) The typical structure of the third *inferior* molar in this species is beautifully shown in a third inferior molar from Simorre reproduced in figure 195 after Gaudry; this left inferior molar shows an external cingulum and trefoils springing from the outer side of the outer cones; it exhibits four complete crests and a half crest

Fig. 4.



Mastodon angustidens.—Vertical longitudinal section of the first lower true molar; from the Middle Miocene of Simorre. ⅔. *b*, enamel; *c*, dentine.

SECOND INFERIOR MOLAR

OBSERVE CENTRAL CONULES IN FIGURES 194–196

Fig. 194. Section of referred "first [?] lower true molar," [M_2], two-thirds natural size. *Trilophodon angustidens*, from type locality of Simorre. After Lydekker, 1886.1, p. 29, fig. 4.

Osborn observes that there is a rudimentary fourth crest (*b*), indicating that this tooth is *not* a first inferior molar, which, as a rule, has only three sharply defined lophs; it is probably a second inferior molar, M_2 (cf. type, Fig. 299).

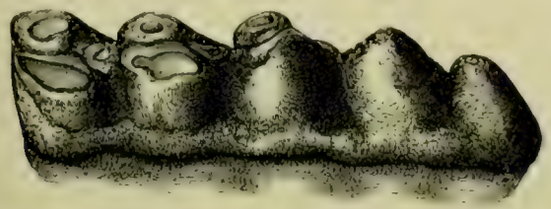


FIG. 227. — Arrière-molaire inférieure du *Mastodon angustidens*, à 1/2 grandeur. — Miocène moyen de Simorre.

LEFT THIRD INFERIOR MOLAR

Fig. 195. Referred four and a half crested third left inferior molar, l.M_3, one-half natural size. *Trilophodon angustidens*, from Simorre. After Gaudry, 1878, p. 172, fig. 227.

Osborn observes that the conule is directly in the center of the valley between the proto- and metalophid. The five crests from front to back of molar are: the proto-, meta-, trito-, tetarto-, and pentalophids. Compare these five crests with the four crests of *Phiomia osborni* (Fig. 185 A1) with its rudimentary tetartolophid, without pentalophid.

representing the pentalophid; compared with the corresponding tooth of *Phiomia osborni* (Fig. 185) it measures great progression in this tooth from Lower Oligocene to Middle Miocene time. (5) The dental succession in *Trilophodon angustidens* is also beautifully displayed in a specimen from Simorre reproduced from a figure by Gaudry one-third natural size (Fig. 197); it exhibits the

SUPERIOR MILK PREMOLARS OF THE LEFT MAXILLA IN THE TRILOPHODONTS AND TETRALOPHODONTS. AFTER GAUDRY (CF. FIG. 181)

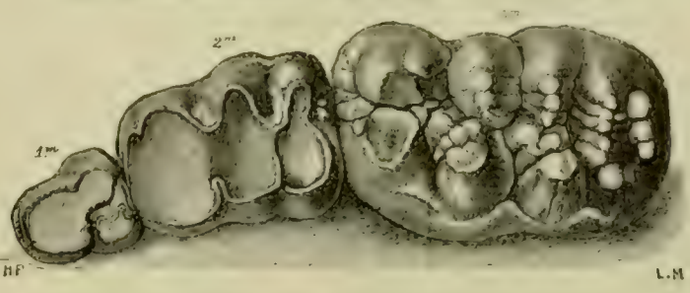


FIG. 240. — Molaires supérieures de lait du *Mastodon longirostris*, aux 2/3 de grandeur. — 1*m*. première molaire; 2*m*. seconde molaire à trois collines; 3*m*. troisième molaire à quatre collines. — Miocène supérieur d'Eppelsheim. (D'après M. Kaup.)

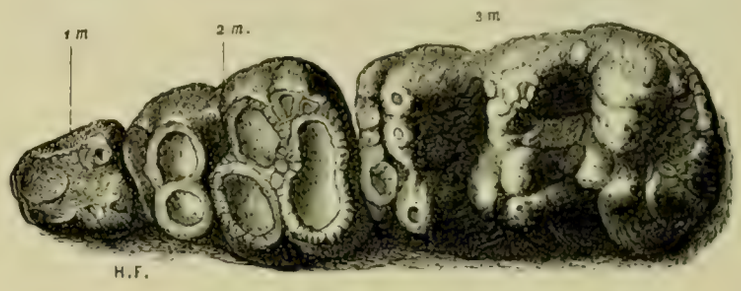


FIG. 241. — Molaires supérieures de lait du *Mastodon Pentelici*, aux 2/3 de grandeur. — 1*m*. première molaire; 2*m*. seconde molaire à trois collines; 3*m*. troisième molaire à trois collines. — Miocène supérieur de Pikermi.

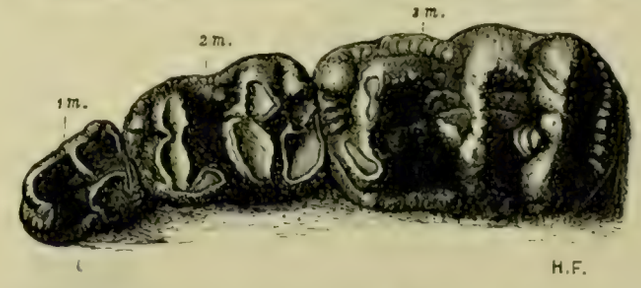


FIG. 239. — Molaires supérieures de lait du *Mastodon angustidens*, aux 2/3 de grandeur. — 1*m*. première molaire; 2*m*. seconde molaire à deux collines; 3*m*. troisième molaire à trois collines. — Miocène moyen de Sansan.

Fig. 196. Succession of teeth, Dp^2, Dp^3, Dp^4, two-thirds natural size, in (lower figure) *Trilophodon angustidens* from Sansan, in (middle figure) type of "*Mastodon pentelici*" from Pikermi, in (upper figure) *Tetralophodon longirostris* from Eppelsheim. After Gaudry, 1878, p. 180, figs. 239, 240, 241.

	Dp^2	Dp^3	Dp^4
Tetralophodon longirostris	1½ crests	3 crests	4⅓ crests
Trilophodon (*Choerolophodon*) *pentelicus*	1½ "	3 "	3⅓ "
Trilophodon angustidens	1½ "	2½ "	3 "
[*Phiomia wintoni* (cf. *serridens*)	1 crest	2 "	3 "]

Compare (1) the above superior milk teeth, Dp^2 to Dp^4, with those of *Phiomia wintoni* (cf. *serridens*), figure 181, and observe the progression in the ridge formula. (2) Observe also the marked crenulation of the sides of the lophs, and (3) the progressive evolution in ascending order of Dp^3 in *Phiomia wintoni* (cf. *serridens*), figure 181, in *Trilophodon angustidens*, in *Trilophodon* (*Choerolophodon*) *pentelicus*, and in *Tetralophodon longirostris* in which Dp^3 becomes trilophodont. Compare *Tri.* (*Choer.*) *pentelicus* in this figure with the same specimen in figure 205 below.

rudimentary Dp_2 (1 *m*), the bilophodont Dp_3 (2 *m*), the trilophodont Dp_4 (3 *m*), also the trilophodont M_1 (1 *a*); beneath the two milk molars (Dp_3, Dp_4) may be observed the permanent P_3, P_4. This milk dentition should be compared with the permanent premolars of *Phiomia wintoni* represented in figure 179 A, also with the milk dentition of *P. wintoni* (cf. *serridens*), figure 181. (6) The crown view of the superior milk molars of *T. angustidens* is also beautifully displayed in figure 196, reproduced from Gaudry; it shows that Dp^2 (1 *m*) is in a rudimentary bilophodont stage, that Dp^3 (2 *m*) is bilophodont with a rudimentary third crest, that Dp^4 (3 *m*) is fully trilophodont; these milk teeth of *T. angustidens* of Sansan are shown to be slightly less progressive than those of *Tetralophodon longirostris* of Eppelsheim.

Matthew, 1920.—Specific references in the table below were taken in the Muséum d'Histoire Naturelle, Paris, 1920. Measurements were taken and indices calculated by W. D. Matthew, 1920–1921. The molar dentition of *Trilophodon angustidens* (Fig. 199) is exceptional in width of M^2, index = 76, and in the extreme narrowness of M_3, index = 39. [= *T. angustidens* of Sansan.]

Frick's Additional Observations of 1926

(1) *Trilophodon angustidens.* Skull and jaw from Tournan, Gers. Collected by Marty. M_2 greatly worn, M_3 third crest worn (vs. M^2 of skull . . . in which third crest only moderately worn). M^3 (142 mm.) heel not quite erupted; M^2 to tip of premaxillary 290 mm.

(2) *Trilophodon angustidens.* Skull from Tournan, Gers, 1887–4. M^2 apparently nearer to state of wear of M_2 of mandible in preceding [specimen] than is M^2 of skull . . . exhibited with same. M^3, 148 mm. [Not in W. D. M. table.]

(3) Skull from Tournan, Gers. 1887 Cat. 4. M^3, 148×73 mm. [Not in W. D. M. table.]

(4) Mounted skeleton, Laurillard. 1851–2 Cat. B VI–5 from Sansan. Skull in bad condition. Teeth of jaws more worn than those of skull (?probably two individuals). M^3 heel as in M_3, largest tubercle on trefoil side, no tendency to cingulum. M^3, 153×75 mm. [150×77 in table.]

(5) Immature mandible from Sansan (*Serridentinus?*). Secured by Filhol, Cat. 22, 1826. Fine condition. [Not in W. D. M. table.]

Molars Referred to Trilophodon angustidens, Middle Miocene (Paris Museum), W. D. Matthew, 1920-1921

	M_2			M_3			M^2			M^3		
	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.
1818, Sansan, Lartet, *T. angustidens*				152	70	46						
T. angustidens				181	78	43						
1851–52, Sansan, mounted skeleton *T. angustidens* (cf. Figs. 199, 200A)	105			176	68	39	94	71	76	150	77	51
1909, Sansan, *T. angustidens*										164	83	51
Type loc.: Simorre, jaws *T. angustidens*	84	55	66	131.5	59	45						
T. angustidens	89	58	65	145	59	41						
1888, Tournan, Marty skull of *T. angustidens*	r.93	63.3	68	160	68	43						
	l.94	60	64	160.4	68	42	100	55	55	[142]	73	

Diameters of I^2: Horizontal, 71 mm.; vertical, 74 mm.
Diameters of I_2: Horizontal, 45 mm.; vertical, 34 mm.

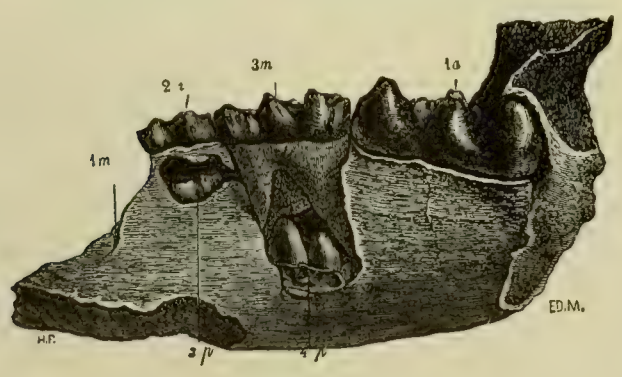


Fig. 242. — Mandibule de *Mastodon angustidens*, vue sur la face interne, au 1/3 de la grandeur. — 1 *m.* alvéole de la première molaire de lait; 2*m.* et 3 *m.* les seconde et troisième molaire de lait; 3 *p.* première prémolaire qui pousse au-dessous de la seconde molaire de lait; 4 *p.* seconde prémolaire qui pousse entre les racines de la troisième molaire de lait; 1 *a.* première arrière-molaire. — Miocène moyen de Simorre (Gers). (D'apres Lartet.)

Fig. 197. Succession of milk and permanent teeth in *Trilophodon angustidens*, one-third natural size. From Simorre. After Gaudry, 1878, p. 182, fig. 242.
$1m = Dp_2$, $2m = Dp_3$, $3m = Dp_4$, $3p = P_3$, $4p = P_4$, $1a = M_1$.

(6) Cat. A-c 2058, 2062. Skull fragment and associated portions of mandible with symphysis broken at tip. M^3 (161)×80 mm. [Not in W. D. M. table.]

(7) Simorre skull. P^4, 42.5 mm., M^1, 74 mm., M^2, 104 mm; M^3, 158×70 mm. 2d cr. [Not in W. D. M. table.]

(8) *Trilophodon* (*Serridentinus?*). A-C 2058 and 2062 from Sansan. Symphysis broken at tusk base, term. expanded similar to *S. productus.* [Not in W. D. M. table. (1933) = Type of *Serridentinus filholi* Frick, 1926–1933, cf. Chap. X, p. 473.]

Cuvier's Type of Trilophodon angustidens.—Second inferior molar, r.M_2, length 116 mm., breadth 60 mm., index 52.

Referred Trilophodon angustidens Indices.—The *seven* specimens referred to *T. angustidens* from Sansan, Simorre, and Tournan represent Middle Miocene stages in which the molar indices are closely similar, although the animals themselves range greatly in size according to sex and geologic succession:

M_2 indices, broadest 68 narrowest 64 average 66
M_3 indices, broadest 46 narrowest 39 average 42.7
M^2 indices, broadest 76 narrowest 55 average 65.5e
M^3 indices, broadest 51 narrowest 51 average 51

Compare measurements of *T. angustidens* molars in table appearing with *Phiomia osborni* (p. 246), also the W. D. Matthew table (p. 256).

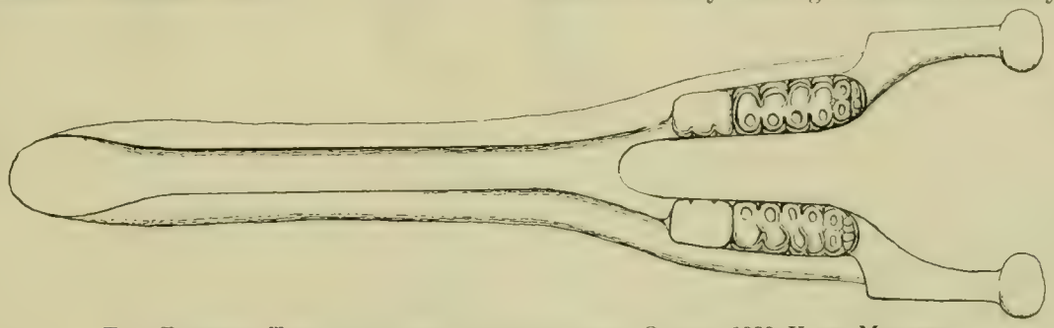
Typical Hyperlongirostrines of France Measured and Observed by W. D. Matthew, 1920. Generic and Specific Nomenclature as in the Present Memoir

Hyperlongirostrines—The Hyperlongirostrines from Sansan, Simorre, and Tournan are readily distinguished by exceptionally elongate, narrow *third inferior* molars, in which the breadth as compared to the length gives the following indices: 39, 41, 42, 43, 45, 46. Until we secure the entire jaw we may not distinguish by the M_3 index alone the Longirostrinæ from the Serridentinæ. Yet it will be seen from the following valuable notes by Matthew that both the excessively long-jawed and the medium-jawed forms occurred in western Europe just as we find them in North America in Miocene time.

Typical Simorre Specimens. Notes by W. D. Matthew, September, 1920.—From Simorre, the type locality of *T. angustidens*, measurements of three specimens containing $M_{2\text{-}3}$ are given above.

Villefranche Specimens (Miocene), W. D. Matthew, September, 1920.—From Villefranche d'Astarac (Gers), in the Lyons Museum, is a *T. angustidens* with the longest jaw and symphysis observed by Matthew in Europe, now raised to the new subspecific rank *Trilophodon angustidens gaillardi* because of its five and a half crested third inferior molars (see p. 259 below); it actually measures 1495 mm., according to a cast of this jaw (Fig. 218) kindly presented to the Museum by Doctor Gaillard (compare *T. angustidens austro-germanicus*, Fig. 201).

Muséum d'Histoire Naturelle, Paris (Childs Frick's Observations of 1926—cf. Frick, 1926.1, pp. 177, 178).—The mature and immature remains heretofore referred in entirety to the Cuvier species, *Trilophodon angustidens*, actually include at least two widely differing forms which broadly considered seem to



Type Figure of Trilophodon angustidens gaillardi Osborn, 1929, Upper Miocene

Fig. 198. Compare new type figure 218. Hyperlongirostrine. Superior aspect of restored jaw referred to "*Mastodon angustidens*," from Villefranche d'Astarac, Gers (St. Gaudens = Sarmatian age) in the Muséum des Sciences Naturelles de Lyon. After pen sketch kindly furnished by Dr. C. Gaillard, Director of the Municipal Museum. About one-twelfth natural size. Observe the five and a half crested M_3, the extremely elongated rostrum, as in *Amebelodon* (*Trilophodon*) *hicksi* Cook (Fig. 261), and the entire *absence* of inferior incisive tusks; hence a progressive or specialized stage. [Incisorless (?) female, cf. *T. phippsi*, *T. cruziensis*, *T.* (*Megabelodon*) *lulli*, and *T. joraki*.]

Trilophodon of Villefranche.—(Depéret, Mayet, letter, 1924): "M. Depéret a cité ce Mastodonte de Villefranche d'Astarac dans son mémoire consacré aux Faunes de vertébrés miocènes publié dans les Archives du Muséum de Lyon, T. IV., p. 181.

Age géologique de la mandibule de Mastodonte de Villefranche d'Astarac. . . . Cette pièce du Muséum d'Histoire naturelle de Lyon, provient des couches d'eau douce du sommet du Vindobonien (sous-étage Sarmatien), de l'horizon de Saint-Gaudens.

Ce *M. angustidens* est un véritable intermédiaire, très intéressant, entre *M. angustidens* de Sansan, et *M. longirostris* du Pontien. C'est un animal *franchement miocène* dont le gisement ne peut absolument pas être regardé comme appartenant au Pliocène. Incisives? Il n'y a sur la pièce aucune trace d'incisives, ni d'alvéoles d'incisives. S'il y en a eu, elles n'ont laissé aucune trace sur le fossile."

Typical Sansan Specimens. Notes by W. D. Matthew, September, 1920.—The *Sansan* stage includes a lower jaw in the Paris Museum of a young individual referred to *Trilophodon angustidens*, but of larger proportions than the skull from Tournan; it equals that of the mounted skeleton in size. This lower jaw shows what Matthew regards as the true position of the lower tusks. In the mounted skeleton of *T. angustidens* (Fig. 199) the upper tusks are finely preserved and their probable[1] relative position is included in the figure; the mandibular symphysis is nearly straight, elongate, and not decurved. From *Sansan* also is a well-preserved skull and jaws of *T. angustidens* (Fig. 200A); the gap between the rami and the symphysis is apparently wrongly restored in this specimen.

parallel respectively (1) the long [= *Trilophodon*] and (2) the moderately-long [= ? *Serridentinus*] symphysised forms of Santa Fé [Mio-Pliocene of New Mexico]. It has seemed advisable to insert at this point a summary of such observations:

(1) [= *Trilophodon*] The first, extremely-long symphysised, and more typical form, is exampled amongst other material from Sansan now in the Museum d'Histoire Naturelle, Paris, by a mandible with broken symphysis and associated skull fragment, by the mandible of the Laurillard mounted skeleton, and by the well preserved immature mandible with p_4, m_2 and tusks figured by Filhol; by the huge mandible in the Muséum des Sciences Naturelles de Lyon [Fig. 198], also by remains from

[1] See caption to Fig. 199, p. 258.

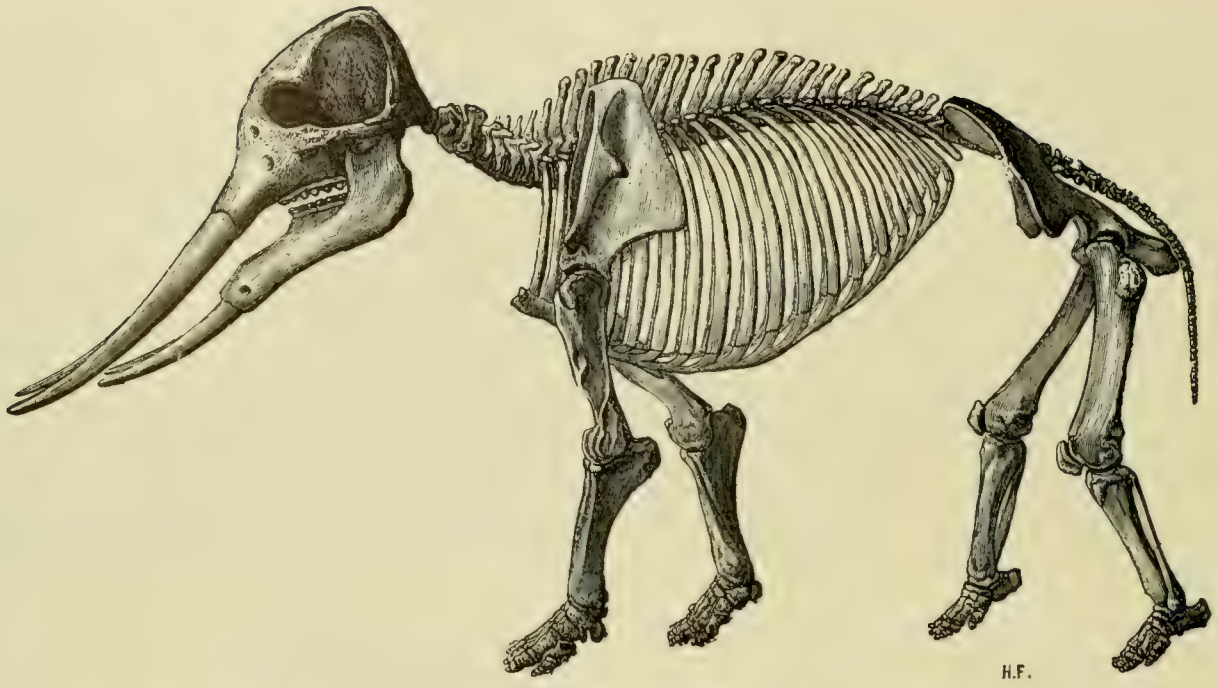


Fig. 226. — Essai de restauration du squelette du *Mastodon angustidens*, d'après les pièces découvertes par Laurillard dans le miocène moyen de Simorre (Gers). Au 1/26 de grandeur.

Composition Skeleton of Trilophodon and (?)Serridentinus from Sansan

Fig. 199. Paris Museum restoration of the skeleton referred to *Trilophodon angustidens*, a faulty composition and restoration from different individuals and species (?) discovered by Laurillard in Sansan (according to label in Paris Museum) not in Simorre as stated by Gaudry. One twenty-sixth natural size. After Gaudry, 1878, p. 171, fig. 226. We can be positive that the skull and jaw represent the typical *Trilophodon angustidens*, but the student should not consider that this composite restoration gives us a truthful presentation of the skeletal characters and proportions of *T. angustidens*. Mus. Nat. Hist., Paris, 1851-2 Cat. B VI-5.

(W. D. Matthew, September, 1920): "*M. angustidens* skeleton, mounted by Laurillard from materials collected by him at Sansan in 1851–1852, with aid of some bones found in the same beds by Lartet. This is a much larger individual than the skull. The skull is defective, and it is not clear just how much of it is original. The lower jaws have apparently been partly restored; the inferior tusks are placed with only the collapsed (hence hollow) roots within the sockets; some of the collapsed part of the tusk is outside the socket. The superior tusks erroneously turn *upwards* instead of downwards [as properly shown in figure 200A]; they are probably in place; the front of the skull seems to be largely original, and the base of the superior tusks outside the socket is slightly collapsed. Ribs mostly restored, pelvis and hind limbs, front limbs, forefeet and some parts of hindfeet original. They are considerably larger than those in the American Museum *Serridentinus productus* skeleton, as is the skull.

Tournan in the Muséum d'Histoire Naturelle, Paris. The specimens cover a large range in size, as well seen in comparison of the anteroposterior lengths of the m_3's, that of the largest m_3 exceeding the smallest by nearly 40 per cent of its own length, and thus suggesting the possible presence of more than the single species. The extreme length of the symphysis is best exhibited by the Lyons mandible [Fig. 218] in which this (symphyseal length 830 mm. versus 'alveolar distance' 420 mm.) and the m_3 (anteroposterior diameter 195 mm.), though of but the typical proportion relative to one another, are of record length. It is interesting to note that the range in size exhibited by this French Miocene material nearly approximates that already observed in the Santa Fé specimens.

(2) [=*Serridentinus filholi* Frick, 1933, type][1] The second, an evidently rarer form, with noticeably shorter proportional symphysis, is definitely represented by a well preserved mandible containing m_2, m_3 and the tusks of both sides, and showing the alveolus of m_1. In this specimen, unlike those above, the 'alveolar distance' (330 mm.) definitely exceeds the symphyseal length (303 mm.), and the m_3 is much less elongate relative to m_2. The anteroposterior diameter of the m_3 is but slightly greater than that of the smallest m_3 of the extremely-long symphysised form.

SKELETAL CHARACTERS OF TRILOPHODON ANGUSTIDENS AND OF SERRIDENTINUS SP. (?)

It is very important to note in all the collections of Europe that the skeletons and the teeth of the true hyperlongirostral *Trilophodon* are intermingled with those of the medilongirostral *Serridentinus*. Skeletons and skulls of these two animals may be intermingled also in some of the restorations and reconstructions. For example, compare the relatively medilongirostral jaw in the '*Mastodon angustidens*' (Fig. 199) after Gaudry, with the hyperlongirostral jaw shown in figure 218 after cast; compare also the medilongirostral skull and jaws in the restoration (Fig. 199) after Gaudry, with the hyperlongirostral skull from Sansan shown in figure 200.

Mounted Skeleton, Muséum d'Histoire Naturelle, Paris. Notes by W. D. Matthew, September, 1920.—From *Sansan*, of typical Middle Miocene age, is the *T. angustidens*

[1]Compare Chapter X (Serridentinæ), Frick's description of *Serridentinus filholi*, page 473.

skeleton (Fig. 199) mounted and restored by Laurillard from materials collected by him in Sansan in 1851–1852, with the aid of some bones found in the same beds by Lartet. The skeleton belongs to a larger individual than the skull from Tournan; the skull itself is defective and partly restored; the lower jaws apparently have also been partly restored; the lower tusks are placed with only the hollow portion of the roots within the sockets, hence they are relatively too long. The front part of the skull seems to be largely original, with the upper tusks probably in place. The ribs are mostly restored, but the pelvis, hind limbs, front limbs, forefeet, and some parts of the hindfeet are original. Both the skeleton and the skull associated with it belong to an animal of larger size than the *Serridentinus productus* skeleton (Fig. 371) of the American Museum.

Skull.—The complete skull and jaws of *T. angustidens* from Tournan belonged to an animal a little larger than that which possessed the small jaws from Simorre mentioned above, but the animal was much smaller than the mounted skeleton from Sansan or the animals to which the larger jaws and teeth from Sansan and

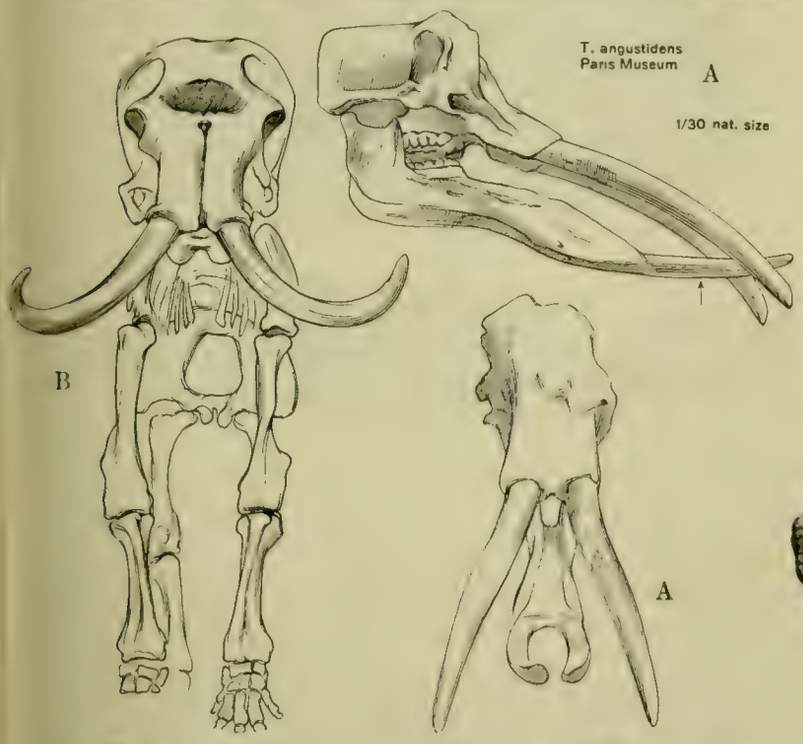


Fig. 200. Left (B). Mounted skeleton of referred *Elephas* [*Archidiskodon*] *meridionalis* of Durfort, in the Paris Museum.

Right (A). Skull of mounted skeleton referred to *Trilophodon angustidens* in the Galerie de Paléontologie, Paris (cf. Fig. 199). After original pencil sketch by Charles R. Knight. This specimen is explained elsewhere as collected chiefly from Sansan, Middle Miocene, France. About one-thirtieth natural size. Compare *T. osborni* (Figs. 248, 256). See restoration (Fig. 169).

Simorre belonged: the adult age of this animal is indicated by M^2-M_2, partly worn, and M^3-M_3, worn only at the anterior end. The actual measurements and indices of the upper and lower teeth in this Tournan skull are given in the table above. The incisive tusks, partly slipped out of their sockets before fossilization, measure respectively: lower tusks approximately 12 in., upper tusks 6 to 12 in.; the upper tusks have a slight downward curvature; the lower tusks curve slightly upwards and the symphysis extends almost directly forward. This skull from the Middle Miocene of Tournan (Gers), found by Marty in 1888, is somewhat inferior in size to the skull of the Lower Pliocene *Serridentinus serridens* of Texas (Fig. 366). A second very incomplete skull also from Tournan, collected by Marty, exhibits little more than the palate and tusks; it is of equally small size, the tusks being more divergent and decurved.

Knight's Sketch of the Sansan Skull.—The value of this sketch by Charles R. Knight (Fig. 200A) is that it shows the front aspect of this important skull as well as the lateral aspect.

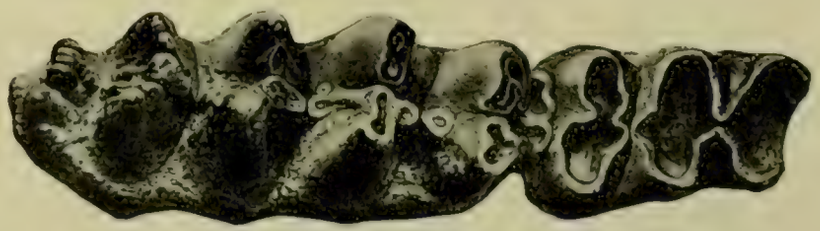
Trilophodon angustidens gaillardi Osborn, 1929

Figures 198, 218B

Villefranche d'Astarac (Gers), France. Recorded as of Upper Miocene age.

Trilophodon angustidens gaillardi Osborn, 1929. "New Eurasiatic and American Proboscideans, Amer. Mus. Novitates, No. 393, Dec. 24, 1929, p. 1, fig. 1 (Osborn, 1929.797).

This subspecific stage from the Miocene of France, based on a jaw in the Muséum des Sciences Naturelles de Lyon, France (cast Amer. Mus. 21904), presented by Doctor Claude Gaillard, is readily distinguished from the typical *Trilophodon angustidens* of Simorre and Sansan by the presence of five and a half ridge-crests in the third inferior molar teeth, as figured above (Fig. 198) by Doctor Gaillard, to whom this subspecies is dedicated, and refigured (Fig. 218) in comparison with *Trilophodon chinjiensis*. The resemblances in size and in ridge-crest evolution to the holotype jaw of *T. chinjiensis* (Fig. 218A, A1, A2) are very close indeed. The same is true of the measurements, as shown in the comparative table below (p. 273). This five and a half ridge-crested third inferior molar (190 mm.) apparently establishes an Upper Miocene stage in Europe and Asia, more progressive than the four and a half ridge-crested Pliocene stages in America.



Type of Trilophodon angustidens var. austro-germanicus

Fig. 201. Type second and third right inferior molars, r.$M_{2\text{-}3}$, of *Mastodon angustidens* var. *austro-germanica* Wegner, 1913, Taf. xv, fig. 2. One-third natural size. "Sämtlich aus dem Obermiocaen von Kgl. Neudorf bei Oppeln. Originale im Palaeontologischen Museum der K. Universität Breslau." Observe conspicuous *central conules*.

Trilophodon angustidens var. **austro-germanicus** Wegner, 1908, 1913

Figure 201

Middle Miocene. Near Oppeln, eastern Germany.

The type right second inferior molar of this species (ap. 116 mm., tr. 71 mm.) is somewhat broader than Cuvier's type r.M_2 (ap. 116 mm., tr. 60 mm.) of *Trilophodon angustidens* (Figs. 190, 299).

Mastodon angustidens var. *austro-germanica* Wegner, 1913. "Tertiaer und umgelagerte Kreide bei Oppeln (Oberschlesien),"

Palaeontographica, Band LX, pp. 255-263. TYPE.—Second and third inferior molars of the right side, r.M_{2-3}. HORIZON AND LOCALITY.—Middle Miocene. From near Oppeln, eastern Germany. TYPE FIGURE.—Wegner, 1913, Taf.xv, fig. 2.

ASSOCIATED FAUNA (WEGNER, 1908, p. 113).—*Amphicyon* sp., *Lutra* sp. (?), *Martes filholi* Depéret, *Sciuropterus gibberosus* Hofmann, *Steneofiber minutus* H. von Meyer, *S. jaegeri* Kaup, *Mastodon* n. sp. Zwischenform von *M. angustidens* und *M. longirostris*.

HISTORY.—(Compare Wegner, 1908, pp. 113, 114) Andreae included in his list of fossil mammals of Oppeln (November 5, 1902) the species *Mastodon angustidens*, a molar tooth from Kgl. Neudorf near Oppeln, without description or figure. None of the Oppeln teeth agrees entirely with the typical *M. angustidens* of Sansan; the specimens include two entirely distinct types. Subsequently Wegner (1913, p. 255) applied the name *Mastodon angustidens* var. *austro-germanica* to the two inferior molars of the right side, r.M_{2-3}.

TYPE DESCRIPTION.—(Wegner, 1913, p. 255): "Von einem mächtigen Unterkiefer, der leider in kleinste Splitter zersprengt wurde, liessen sich noch die beiderseitigen M_2 und M_3 zusammensetzen, von denen die rechtsseitigen auf Tafel xv, Fig. 2 abgebildet sind. Der M_3 besitzt 5 Joche und einen kleinen knöpfchenförmigen Talon. Die Quertäler sind breitbodig und weit ausgebuchtet, die Jochwände glattwandig, nur bei den beiden letzten Jochen rauhwandig oder gerunzelt, diese letzteren sind auch nicht ganz geradegestreckt, denn die hier deutlicher durch Einschnitte voneinander markierten einzelnen Höcker, welche die Joche zusammensetzen, stehen in einem flachen Halbbogen. Die Medianfurche ist ziemlich tief eingeschnitten, Sperrhöcker sind besonders in den beiden vordersten Quertälern gut entwickelt."

Osborn, 1926: *Subspecific characters.* This beautiful type is a transition between the four-crested and five-crested stage; behind the pentalophid is the rudiment of a hexalophid; consequently it is somewhat more progressive than the third lower molar of Simorre (cf. Fig. 195), which has five crests without the rudiment of a sixth; it is much more progressive than the referred *Trilophodon cooperi* (Fig. 213); it is less progressive than the jaw from Villefranche d'Astarac (Fig. 218). It appears, therefore, to represent a valid subspecies or ascending mutation.

MEASUREMENTS.—Right M_2, ap. 116 mm., tr. 71 mm., index 61. Right M_3, ap. 214 mm., tr. 83 mm., index 39. These proportions compare quite closely with the *Trilophodon angustidens* of Sansan also with the hyperlongirostral species of America, as follows:

	ap.	tr.	I.
Referred *Trilophodon angustidens*, Sansan, M_3	176	68	39
Type of *Trilophodon angustidens* var. *austro-germanicus*, M_3	214	83	39
Type of *Trilophodon* (*Megabelodon*) *lulli*, M_3,	222	89	40
Type of *Amebelodon* (*Trilophodon*) *hicksi*, M_3	199	80	40
Type of *Amebelodon* (*Trilophodon*) *paladentatus*, M_3	174	79	45
Type of *Trilophodon osborni*, M_3	190[196]	76[80]	40[41]
Type of *Trilophodon abeli*, M_3	185	76	41
Type of *Amebelodon fricki*, M_3	229	89	39

NOTE (1931).—The species Mastodon [=Trilophodon] engelswiesensis, M. [T.] esselbornensis, and M. [T.] steinheimensis of Klähn, 1922, are treated on pages 281 and 282 of the present chapter (VIII).

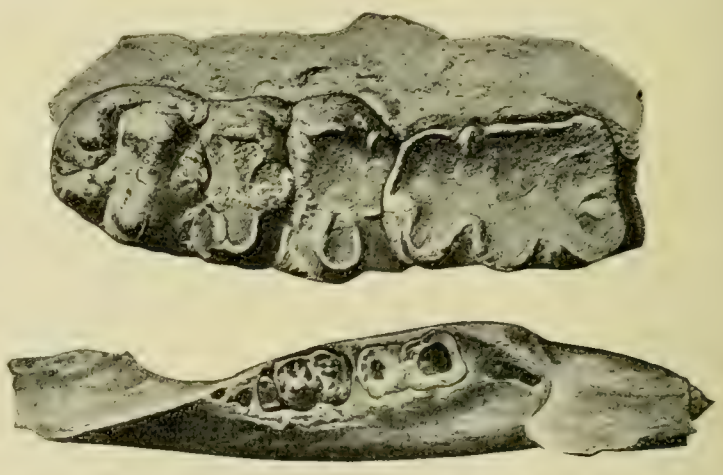
NOTE (1933).—See pages 283 and 284 for description of Trilophodon pontileviensis.

Trilophodon angustidens var. libycus Fourtau, 1918

Figure 202

(?)Lower Miocene, Moghara, northern Egypt, Africa.
Compare *Rhynchotherium*.

The race *libycus* is regarded by its author as a Trilophodont intermediate between the *Trilophodon angustidens* ref. of the Orléanais and the *M. angustidens pontileviensis* of the Blésois. Osborn compares this very primitive four-crested M^3 stage with the four-crested M^3 of *Trilophodon fricki* of Colorado (Fig. 267, p. 313).



TYPE OF TRILOPHODON ANGUSTIDENS VAR. LIBYCUS

Fig. 202. Type of *Mastodon angustidens*, Cuvier var. *libyca* Fourtau, 1918, fig. 58, with correction of dental symbols by the present author.

(Upper figure) M^2, M^3, of the left side, one-third natural size. From the desert of Moghara, Egypt.

(Lower figure) Superior view of referred left lower jaw (*op. cit.*, fig. 59), one-fourth natural size; same locality.

Observe *central conules*.

Osborn (1924) observed that, whereas the *central* position of the trefoil conules relates this animal to the Longirostrinæ, the relatively short and broad proportions of M^3 (index 60), as compared with *Trilophodon angustidens* (index 51), suggest the inquiry whether this animal may not be related to the Rhynchorostrinæ rather than to *Trilophodon* of the true Longirostrinæ. Osborn (1935) observes that *Trilophodon libycus* of the Lower Miocene of northern Africa, with its primitive four-crested M^3 (ap. 143 mm., tr. 86 mm., I. 60), is very similar to M^3 of *T. fricki* of Colorado (ap. 162 mm., tr. 82 mm., I. 51), the most primitive stage thus far discovered in America (see Fig. 267).

Mastodon angustidens, Cuvier var. *libyca*, Fourtau, 1918. "Contribution à l'Étude des Vertébrés Miocènes de l'Égypte." Ministry of Finance, Egypt, Survey Department, 1918, pp. 84–89. TYPE.—(*Op. cit.*, p. 84): "Seconde et troisième molaires supérieures gauches." HORIZON AND LOCALITY.—(?)Lower

Miocene, Moghara, northern Egypt, Africa. TYPE FIGURE.—*Op. cit.*, p. 84, fig. 58.

TYPE DESCRIPTION.—(*Op. cit.*, p. 85): "Je me bornerai donc à quelques détails sur les pièces récoltées à Moghara. (1) Un fragment de maxillaire supérieur gauche nous montre M_2 et M_3 [M^2-M^3]. M_2 [M^2] est fortement usée, on ne voit que sur les bords les traces de sa disposition trilophodonte, elle a 107 millimètres de long sur 68 millimètres de large. M_3 [M^3] est à quatre collines, sa longueur est 143 millimètres, sa plus grande largeur au niveau de la première colline 86 millimètres et sa moindre largeur au niveau de la quatrième colline 60 millimètres. Les mamelons sont de hauteur médiocre, les vallées qui séparent les collines sont assez larges et obstruées au milieu par un assez gros mamelon accessoire. Le talon est peu développé et accolé à la quatrième colline de telle sorte que cette dernière semble en faire partie, ses mamelons sont d'ailleurs beaucoup moins développés que ceux des trois premières mais plus hauts que les mamelons accessoires du talon. Le bourrelet basilaire est très net sur la face interne de la dent entre le talon et la première colline; à la face externe, on ne constate sa présence qu'au tiers antérieur où il embrasse la moitié postérieure de la première colline et la moitié antérieure de la seconde."

Osborn, 1923: The imperfect type of this subspecies, *Trilophodon angustidens libycus*, interesting and important as coming from the Miocene of Moghara, North Africa, should be compared with the contemporary *Rhynchotherium spenceri* also from Moghara (Fig. 455). The dental measurements given by Fourtau exceed those in the large mounted skull from Sansan, namely:

	M^2			M^3		
	ap.	tr.	I.	ap.	tr.	I.
1851-1852, Mounted Sansan skull of *T. angustidens*, Paris Museum	94	71	76	150	77	51
Type of *Trilophodon angustidens libycus*	107	68	63.55	143	86	60

These indices of *T. angustidens libycus* do not agree very well with those of the typical *T. angustidens*, the last superior molar being relatively broader in *T. angustidens libycus*.

(Joleaud, 1920, p. 497): "Les Proboscidiens comptent le *Mastodon angustidens libyca* Fourt. et le *M. Spenceri* Fourt. La race *libyca* de *M. angustidens* serait intermédiaire entre le Mastodon du Burdigalien de l'Orléanais et le *M. angustidens pontileviensis* Mayet de l'Helvétien du Blésois. Elle est en tout cas incontestablement plus différenciée que le *M. a. pygmæus* du Burdigalien inférieur de Kabylie. Ces données paléontologiques indiquent l'âge précis du gisement de Moghara, qui se place entre la phase de dépôt des sables de l'Orléanais (Burdigalien) et celle des faluns du Blésois (Helvétien). Une telle manière de voir s'accorde avec le stade d'évolution constaté chez le *Teleoceras* de Moghara, qui est aussi intermédiaire entre la forme burdigalienne (*T. aurelianense*) et la forme helvétienne (*T. brachypum*). . . . Le *Mastodon Spenceri* viendrait prendre place entre le *M. angustidens* et le *M. longirostris*, entre les sections *Trilophodon* et *Tetralophodon:* le Burdigalien supérieur de Moghara confinerait ainsi à l'époque et à la contrée où s'est effectuée la différenciation des types de *Mastodon*."

8. TRILOPHODON (CHOEROLOPHODON) OF SOUTHEASTERN EUROPE (PIKERMI, SAMOS), AND ASIA (MARAGHA, PERSIA)

TRILOPHODON (SUBGENUS: CHOEROLOPHODON Schlesinger, 1917)

Original reference: Schlesinger, 1917, Denk. Naturhist. Hofmus., I, Geol.-Pal., Reihe I, p. 181.
Genotypic species: *Mastodon pentelicus* Gaudry and Lartet, 1856.
Choerolophodon, based on immature specimens, is probably a synonym of *Trilophodon*.

SUBGENERIC CHARACTERS OF CHOEROLOPHODON.—In 1917 Schlesinger (p. 181) separated the subgenus *Choerolophodon* as follows: "Choerodonte Reihe. Subgenus: *Choerolophodon n. sg.* Schädel niedrig, langgestreckt mit zwei aufwärts und auswärts geschwungenen schmelzbandlosen Stosszähnen. Unterkiefer mit mässig langer Symphyse ohne untere Inzisoren. Molaren choerodont (hochgradig suid)."

(Schlesinger, 1922, p. 260): "5. Choerodonten: *a*) Langbleiben des Schädels, niederer flacher Dom. *b*) Langbleiben der Mandibel und ihrer Symphyse. *c*) Schmelzbandverlust an I^2. *d*) Aufwärts und Auswärtskrümmung der I^2, breitovaler Querschnitt. *e*) Schwund der I_2. *f*) Reduktion der Molarenzahl. *g*) Konstanz der Trilophodontie (atypisch). *h*) Prämolarenschwund."

Osborn, 1932: External enamel band present on Di^2 (Fig. 206) contrary to Schlesinger's definition.

All of Doctor Schlesinger's material, which is fully described and figured below, consists of juvenile skulls and jaws containing deciduous superior and inferior premolar teeth which in many characters closely resemble those of *Trilophodon* (Fig. 196 after Gaudry and Fig. 208 after Schlesinger). Consequently *Mastodon pentelicus*, selected by Schlesinger as the genotypic species of *Choerolophodon*, is much more closely related to *Trilophodon* than to *Tetralophodon*. The question still remains whether *M. pentelicus* is to be regarded as generically related

to *Trilophodon*; this question appears to be answered in the affirmative by the discovery in the island of Samos by Barnum Brown of a more mature palate containing Dp^3-M^1 (Fig. 207) which reveals close affinity to, if not synonymy with, *Trilophodon*.

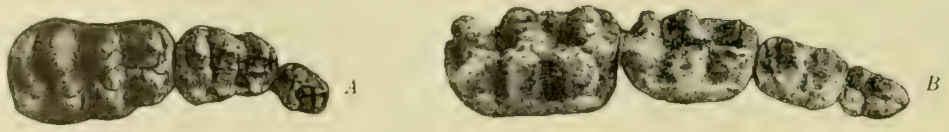


Fig. 203. Milk dentition of (B) *Trilophodon* and of (A) *Tetralophodon*. After Schlesinger, 1917, Taf. II, fig. 2, Taf. XII, fig. 1, one-third natural size.

A, Juvenile right superior dentition, Dp^2-Dp^4, referred to *Mastodon* (*Bunolophodon*) *longirostre* Kaup, after Schlesinger, 1917, Taf. XII, fig. 1. Stirling sandgrube am Geierach, Austria.

B, Juvenile right superior dentition, Dp^2-M^1, referred to *Mastodon* (*Bunolophodon*) *angustidens* Cuv., after Schlesinger, 1917, Taf. II, fig. 2. From Guntersdorf bei Grund, Austria.

Hopwood (letter, Feb. 10, 1932) regards the chœrodont *M. pentelicus* of Pikermi and Samos, type of *Choerolophodon* Schlesinger, as comparable with *Synconolophus* Osborn of the Dhok Pathan, an opinion apparently sustained by Schlesinger (1917) in his reference of many specimens to *Mastodon pandionis* which are considered by Hopwood as belonging to *Synconolophus*. Osborn (1932) does not accept this opinion, for the reason that despite the superficial chœrodont resemblances in the molars, the *cranium* of *Synconolophus dhokpathanensis* (Fig. 305) is fundamentally different from the cranium either of *Trilophodon osborni* (Fig. 253) or of *Tetralophodon punjabiensis* (Fig. 306), as shown in direct comparison of *Synconolophus* and *Tetralophodon* in Chapter IX below.

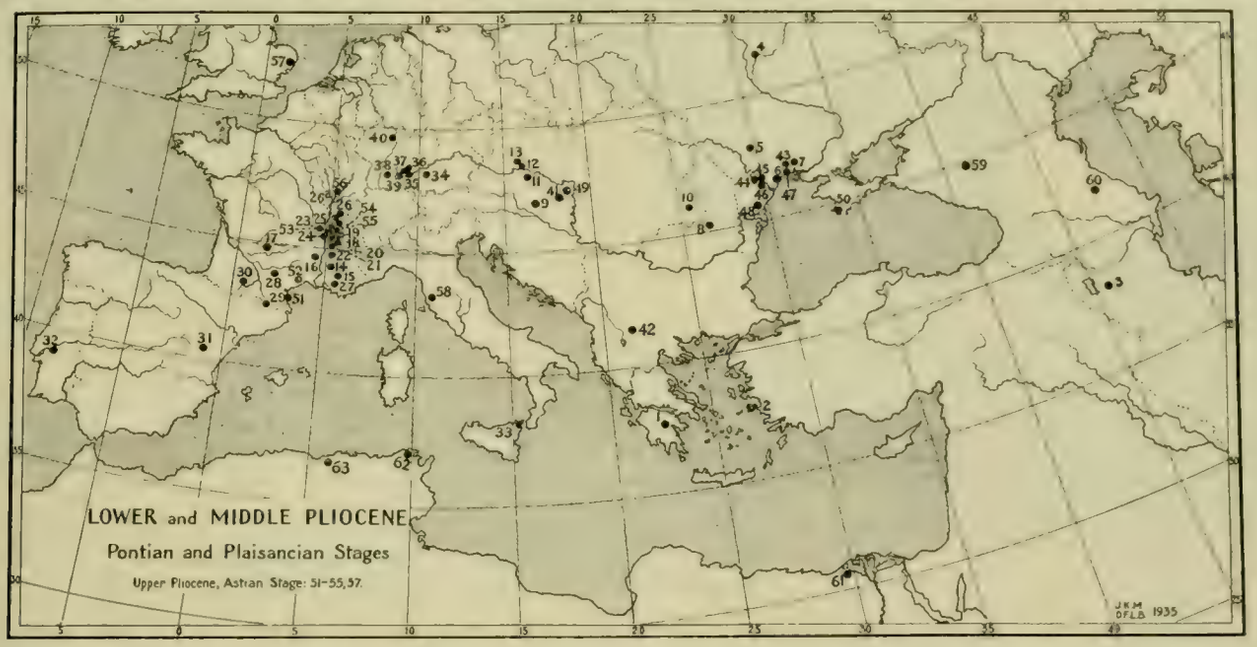
'Choerolophodon' rests upon the genotypic species *Mastodon pentelicus* of Gaudry and Lartet. Schlesinger's citation of Pikermi and Samos materials is as follows (*op. cit.*, 1917, p. 181):

> Weitaus die hervorragendsten Reste von Mastodonten, die das Wiener Hofmuseum beherbergt, gehören dem von Gaudry aus Pikermi bekanntgemachten *M. Pentelici* Gdy. et Lart. zu. Sie stammen durchgehends von zwei Fundorten: von der Insel Samos im Ägäischen Meer und aus Maragha am Urmiasee in Persien. Die prachtvollen Reste, die mir vorlagen, ermöglichten mir einen sehr vollständigen Einblick in die Morphologie der Art und zeigten mir ihre ganz besondere Stellung unter den Gruppen der Mastodonten. *M. Pentelici* muss als ein bunodonter oder besser suider Vertreter seiner Gattung gelten, ist aber im ganzen von der Gruppe *Bunolophodon* derart verschieden, dass ich mich veranlasst sehe, es als Angehörigen einer besonderen Untergattung zu betrachten, für die ich infolge des weitgehend schweineartigen Molarenbaues den Namen *Choerolophodon* vorschlage. Die schönsten Reste sind drei fast vollständige Schädel aus dem Unterpliozän von Samos. Ich benenne sie der Grösse nach mit den Buchstaben, A, B und C.

Geographic Distribution of 'Choerolophodon.'—After reviewing the geographic distribution in Austria and Hungary, Schlesinger (*op. cit.*, 1922, pp. 217, 219) concludes (p. 219): "Nach alldem steht der Horizont als unterer Abschnitt des Oberpontikums (Mittelpontikum n. Gy. v. Halaváts) fest. . . . Die eben angeführten Momente hindern mich, Betrachtungen über die beiden ausländischen Fundorte dieser Art, Kertch (Bessarabien) und Maragha (Persien) anzustellen. Für so ferne Gegenden dürfte es doch geraten sein, mit dem Urteil vorläufig noch zurückzuhalten. Bezüglich Maragha kann ich nicht umhin hervorzuheben, dass ein oberpontisches Alter auch von der Seite her wahrscheinlich ist, dass die Gesamtfauna die nächsten Beziehungen, zu der von Samos, Pikermi und auch Baltavár zeigt, welch leztere wir als zum hohen Oberpontikum gehörig erkannt haben (vgl. S. 187). . . . [p. 234] Sämtliche Fundorte, von denen wir *M. Pentelici* kennen, Pikermi, Samos, Maragha und Halbinsel Krim sind ihrer näheren Horizontzuteilung nach unbestimmt. Von den ersten drei Stellen wissen wir zwar nach den Begleitfaunen, dass sie unterpliozän sind, doch ist von keiner aus den Lagerungsverhältnissen oder nach Funden von Wirbellosen eine genauere Zuteilung möglich. Aus der Tatsache, dass alle drei, durch ausserordentlichen Wirbeltierreichtum ausgezeichneten Lokalitäten dem Unterpliozän angehören, sind wir wohl in der Lage *M. Pentelici* als unterpliozäne Form festzuhalten. Dagegen fehlt jeder Anhaltspunkt, mehr über den stratigraphischen Wert der Art zu sagen."

Fig. 204. Lower Pliocene (=Étage Pontien), correlation of western Eurasia; *Hipparion* zone, chief localities; after Depéret (1905-1908) and Osborn (1910.346, p. 267, fig. 134, "Upper Miocene").

Middle Pliocene (=Etage Plaisancien) as far east as the Caspian Sea, localities in part. Upper Pliocene (=Étage Astien), a few important localities.



LOWER AND MIDDLE PLIOCENE. Pontian. GREECE.—Red limonite of **1** *Pikermi*. ASIA MINOR.—**2** *Isle of Samos*. PERSIA.—**3** *Maragha*. RUSSIA. **4** *Tchernigov*. **5** Sands of *Balta* (Podolia). Limestone of **6** *Odessa*, **7** *Groussolowo* (Kherson). ROUMANIA. **8** *Mânzați*. HUNGARY.—**9** *Baltavár*. ROUMANIA.—Lignites of **10** *Baroth-Köpecz*. AUSTRIA.—**11** *Siebenhirten*. Congeria gravels of **12** *Vienna basin*. **13** *Eggenburg*. FRANCE.—Limons rouges de **14** *Mont Léberon* (Vaucluse). **15** *Visan* (Vaucluse). **16** *Aubignas* (*Ardèche*). Cinerites de **17** *Puy-Courny* (Cantal). Lignites de **18** *St-Jean-de-Bournay*, **19** *La-Tour-du-Pin* (Isère). Marnes de **20** *La Trappe de Chambaran* (Isère). **21** *Mont Mirail* (Drôme). Lignites de **22** *Tersanne* (Vaucluse). Mollasse de **23** *La Croix-Rousse* (Ain), freshwater. **24** *Sainte-Foy à Lyon*, near Lyons. Mollasse d' **25** *Ambérieu* (Ain), freshwater. **26** *Soblay* (Ain). **26a** *St-Jean-le-Vieux* (Ain). **27** *Rocher du Dragon*, near Aix (Bouches-du-Rhone). Marnes de **28** *Montredon* (Hérault). **29** *Estavar* (Cerdagne), lacustrine. **30** *Aurignac* (Haute-Garonne). SPAIN.—**31** *Concud* (Arragon), lacustrine. PORTUGAL.—**32** *Archino*, on the Tagus. SICILY.—**33** *Grasitelli*, near Messina. GERMANY.—**34** *Salmendingen* (Bavaria). Bohnerz von **35** *Melchingen*. **36** *Trochtelfingen*, **37** *Ebingen*, in Swabia. **38** *Undingen* (Baden). **39** *Heuberg* (Swabia). Kies von **40** *Eppelsheim*, near Worms (7–10 meters). HUNGARY.—**41** *Polgárdi*. JUGOSLAVIA.—Sands of **42** *Veles*, on the Upper River Wardar. RUSSIA.—**43** *Kouyalnik*. **44** *Tiraspol*. **45** *Grebeniki*. **46** *Tschobroutschi*. **47** *Novo Elisavetovka*. **48** *Taraklia*. HUNGARY.—**49** *Csákvár*. RUSSIA.—**50** *Sebastopol*.

Plaisancian and Astian. FRANCE.—Sables siliceux gris de **51** *Perpignan*. Sables marins de **52** *Montpellier* (Hérault). Sables de **53** *Trévoux*. Cailloutis de **54** *Montluel*. Tufs de **55** *Meximieux* (Saône Valley). Minerai de fer d' **56** *Autrey*, lacustrine. ENGLAND.—**57** Red Crag of *Suffolk*. ITALY.—Lignites of **58** *Casino* (Tuscany). RUSSIA.—**59** *Stavropol*. **60** *Eldar*. EGYPT.—**61** *Wady-Nâtrun* (estuarine). TUNIS.—**62** *Bizerta*. ALGERIA.—**63** *Aïn-el-Hadj-Baba* and *Aïn-el-Bey* (**Plaisancian-Astian?**).

Trilophodon (**Choerolophodon**) **pentelicus** Gaudry and Lartet, 1856, 1859, 1862

Figures 205–208

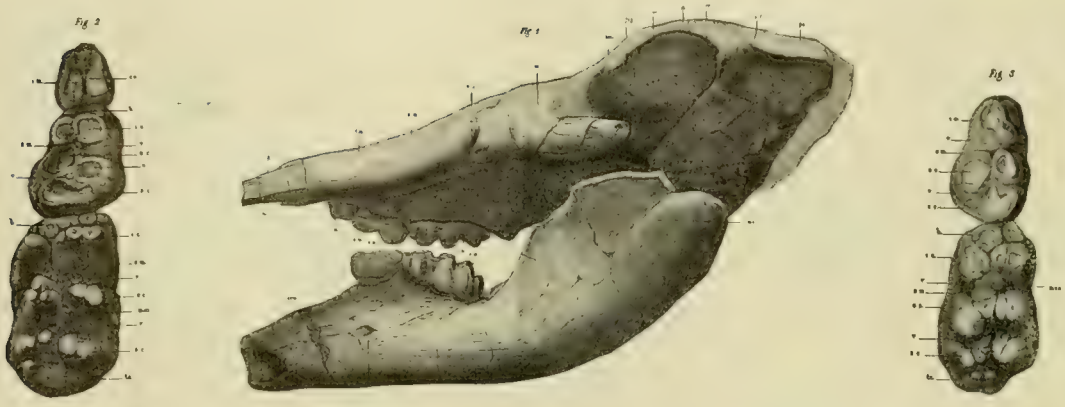
Lower Pliocene of Pikermi, Greece, of the same geologic age as Eppelsheim, Germany.

Mastodon pentelicus is the genotypic species of the subgenus *Choerolophodon*. *Mastodon atticus* Wagner has long been regarded as synonymous with *Mastodon pentelicus* Gaudry; this is an error. Wagner's figure of *M. atticus*, 1857, Tab. VII, fig. 16, proves that this is a Zygolophodont and consequently it becomes the type of *Turicius atticus* Wagner, 1857, as explained in Chapter VII above, subfamily Zygolophodontinæ.

The species *Trilophodon* (*Choerolophodon*) *pentelicus* (Fig. 205), thus far known chiefly from juvenile crania and jaws from Pikermi and Samos, is distinguished by only 3⅓ crests in Dp^4-Dp_4, whereas in *Tetralophodon longirostris* of the same geologic age there are 4½ crests in Dp^4 (see Fig. 196, *M. longirostris*).

HISTORY OF 'M.' PENTELICUS AND 'M.' ATTICUS.—In 1856, p. 273, Gaudry and Lartet named the juvenile Pikermi skull with milk dentition '*Mastodon pentelicus*.' In 1857 Wagner erroneously cited the animal (Wagner, 1857, p. 140) as: "11. *Mastodon atticus* G. & L.," thus apparently attributing the species to Gaudry and Lartet but under another name. In Pl. VII, fig. 16, he referred to this species a maxillary fragment of another individual. On page 142, Wagner makes reference to this species, as follows: "In meinen früheren Erörterungen dieser Ueberreste habe ich es nicht gewagt, sie einer bestimmten Spezies von Mastodon zuzuweisen. Gaudry und Lartet haben sie jetzt als *Mastodon atticus* bezeichnet; ihre ausführliche Abhandlung, die noch nicht erschienen ist, wird jedenfalls die Gründe angeben, warum sie dieselbe von M. angustidens getrennt haben." Gaudry observed (1862, p. 142, footnote): "(1) C'est par une inadvertance de copie que Wagner a employé le nom d'*atticus:* car il nous attribue ce nom, et le seul que nous ayons proposé est celui de *pentelicus*."

In 1862 Gaudry fully described and figured the juvenile type of *M. pentelicus*. In 1917 Schlesinger proposed the subgenus *Choerolophodon*, in reference to the *chærodont* character of these milk teeth, based on Gaudry's specific type, namely, the '*Mastodon pentelici*' of Pikermi. In 1922 Schlesinger described from the island of Samos a juvenile cranium and milk dentition (Fig. 208) as '*Mastodon* (*Choerolophodon*) *pentelici*,' as reprinted in full and figured below. Meanwhile (1856–1925) no *adult* grinding teeth had been described; consequently in Osborn's opinion (1923) the validity of the subgenus *Choerolophodon* remained in question. In



TYPE OF TRILOPHODON (CHOEROLOPHODON) PENTELICUS

Fig. 205. Juvenile type skull and teeth of *Mastodon pentelicus* Gaudry and Lartet, 1856. After Gaudry, 1862, Pl. XXII, figs. 1–3. Skull one-sixth natural size; teeth one-third natural size. (Left) Fig. 2. Dp^2, Dp^3, Dp^4. (Right) Fig. 3. Dp_3, Dp_4. Compare the excellent engraving (Fig. 196 above) of the superior milk teeth of *M.* [*Trilophodon* (*Choerolophodon*)] *pentelicus*, reproduced from Gaudry (1878, p. 180), and observe their fundamental resemblances to the superior milk teeth referred to *Trilophodon angustidens* from Sansan; they are less tuberculate and chœrodont than the superior milk teeth of *Tetralophodon longirostris* from Eppelsheim, as figured by Gaudry (*op. cit.*, fig. 240). The superior milk molars of *Trilophodon* (*Choerolophodon*) *pentelicus* are certainly intermediate in character between those of *Trilophodon angustidens* and those of *Tetralophodon longirostris*, and do not represent a separate phylum. Compare figures 196 and 206, of the same specimen, in the present Memoir.

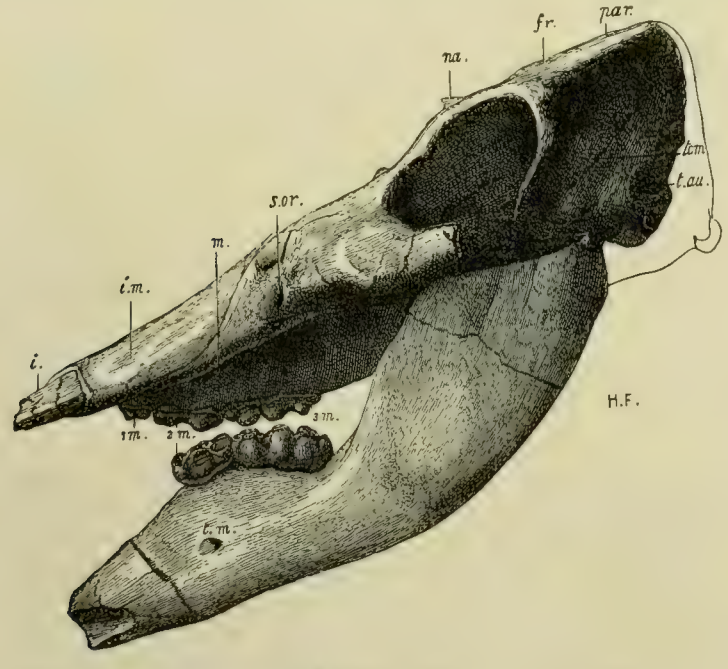


FIG. 244. — Crâne d'un jeune *Mastodon Pentelici*, au 1/5 de grandeur. — *i.m.* inter-maxillaire; *m.* maxillaire; *s.or.* trou sous-orbitaire; *na.* nasal; *fr.* frontal; *par.* pariétal; *tem.* temporal; *t.au.* trou auditif; *t.m.* trou mentonnier; *i.i.* incisive supérieure et alvéole de l'incisive inférieure; *1m.*, *2m.*, *3m.* les molaires de lait. — Miocène supérieur de Pikermi.

TYPE OF TRILOPHODON (CHOEROLOPHODON) PENTELICUS

Fig. 206. Juvenile type skull and teeth of *Mastodon pentelicus* Gaudry and Lartet, 1856. After Gaudry, 1878, p. 184, fig. 244. One-fifth natural size.

This is a very young animal with deciduous incisors and premolars; intermediate molars trilophodont in ridge formula, bunolophodont in cone structure; enamel band on the outer side of the superior tusks; lower jaw moderately elongated. The teeth *in situ* are Dp^2, Dp^3-Dp_3, Dp^4-Dp_4.

1924, however, Barnum Brown discovered in the island of Samos a maxilla (Amer. Mus. 20703—Fig. 207 of the present Memoir), containing the three intermediate molars, Dp^3, Dp^4, M^1, which does not strengthen the establishment of the subgenus *Choerolophodon* as an aberrant chœrodont branch of the genus *Trilophodon*.

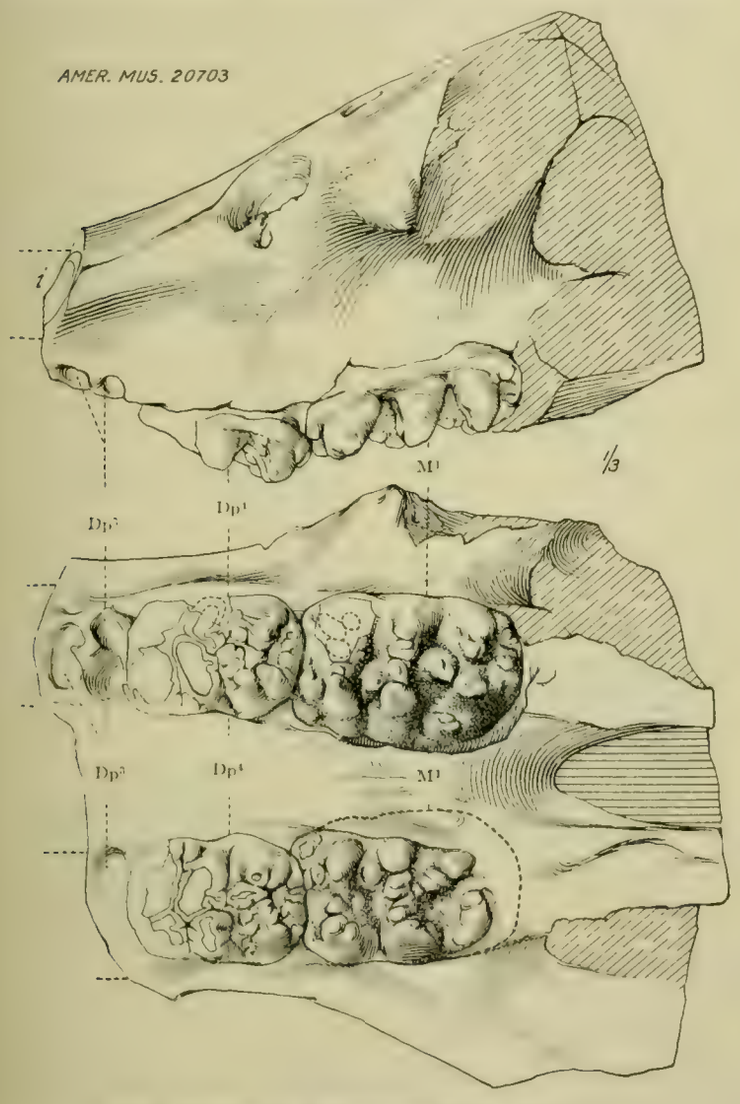
Mastodon pentelicus Gaudry and Lartet, 1856. "Résultats des recherches paléontologiques entreprises dans l'Attique sous les auspices de l'Académie," Compt. Rend. Acad. Sci. Paris, Tome XLIII, p. 273 (name only); 1859, Lartet, "Sur la dentition des proboscidiens fossiles (Dinotherium, Mastodontes et Éléphants) et sur la distribution géographique et stratigraphique de leurs débris en Europe," Bull. Soc. Géol. de France, (2), Tome XVI, p. 497; 1862, Gaudry, "Animaux Fossiles et Géologie de l'Attique," pp. 142–152. TYPE.—Skull and teeth of a young individual. HORIZON AND LOCALITY.—Lower Pliocene of Pikermi, Greece. TYPE FIGURE.—Gaudry, 1862, Pl. XXII. TYPE DESCRIPTION.—(Lartet, 1859, footnote, p. 497): . . . "sous la dénomination *provisoire* de *Mastodon pentelicus?*, quelques ossements et un maxillaire supérieur d'un jeune individu dont les dents n'ont pas pu être rigoureusement identifiées avec celles d'aucune espèce connue."

TRILOPHODON (CHOEROLOPHODON) PENTELICUS OF SAMOS AS DESCRIBED BY SCHLESINGER, 1922

In the following description Schlesinger uses the older symbols, M 1, M 2, M 3, instead of the newer symbols of Osborn, namely, Dp 2, Dp 3, Dp 4, M 1, etc. For example, Schlesinger describes the dentition of the juvenile cranium discovered in the island of Samos (Schlesinger, 1922, Taf. XX, XXI) as M 1–M 3 instead of Dp $^{2\text{-}4}$, Dp $_{2\text{-}4}$. This juvenile skull and jaws (reproduced in our Fig. 208), referred to the same species as the *Mastodon pentelicus* Gaudry and Lartet, of Pikermi, serves to modify Schlesinger's distinction of his subgenus *Choerolophodon*.

SAMOS SKULL.—(Schlesinger, 1922, p. 142): "Ausser den schönen und überaus wertvollen Resten heimischer Mastodonten beherbergt die Sammlung der ung. geologischen Reichsanstalt auch einen recht guten Schädel samt Unterkiefer von *M. Pentelici* aus den bekannten Pliozänlagen von Samos (Inv.-Nr. Ok/549). . . . Die Stosszähne sind als Stummeln entwickelt. Die Prämaxillarteile, in welchen sie sitzen, sind zum Teil weggebrochen. Die Knochennähte sind nur schlecht und an wenigen Stellen sichtbar. . . . [p. 145] Doch illustriert und bestätigt diese Ähnlichkeit der Verhältnisse von einer ganz unerwarteten Seite meine Behauptungen [Footnote: 'F. E. Beddard: On the brain of the African Elephant, Proc. Zool. Soc. 1893, p. 311, Pl. XXIII. London, 1893.']

über die grundlegende Verschiedenheit hochdomiger und flachdomiger Proboszidiercranien. *M. Pentelici* gehört zu der Gruppe von Rüsseltieren, die sich durch einen ganz unerhört flachen und langgestreckten Schädel auszeichnet. Aus dieser osteologischen Tatsache ist auch die schlanke und verhältnismässig gestreckte Grosshirnform erklärlich. Wie diese Schädelform, so ist auch diese Art Hirnform als der ursprüngliche Zustand aufzufassen. Die Entwicklungsmechanik des Proboszidiercraniums wird also auch von dieser Seite her in derselben Richtung beleuchtet, in die ich wiederholt mit Nachdruck gewiesen habe . . . [p. 147] Die Inzisoren sind klein, schwach, abgerundet und stummelartig und trotz des höheren Alters des Tieres schwächer, als am Cranium B. Der m^1 [Dp^2] ist auch hier aus einem grossen vorderen, an der Aussenseite gelegenen Höcker und einem eng angepressten kleineren innen zusammengesetzt. Rückwärts folgen wieder die beiden typischen kleinen Hügel, deren innerer stärker ist. Ein Basalwulst ist vorne deutlich. Der m^2 [Dp^3] wiederholt die Merkmale der Wiener m^2. Der Basalwulst ist kräftig, hinten zu einem mächtigen Talon verstärkt, der aus vielen Mammillen besteht, die sich prätriterseits verdichten. Von den zwei Jochen hält das erste die Querfläche der



Milk Dentition of Referred Trilophodon (Choerolophodon) pentelicus

Fig. 207. Superior milk dentition of referred *Trilophodon* (*Choerolophodon*) *pentelicus* (Amer. Mus. 20703), from the island of Samos. Brown Coll.

The trilophodont fourth superior milk premolar, Dp^4, resembles in measurement and form the corresponding milk premolar of Gaudry's type of *Mastodon pentelicus* (Gaudry, 1862, Pl. xxii, fig. 2) reproduced in figures 196 and 205 of the present Memoir. M^1 exhibits two large *central conules* in the median valleys.

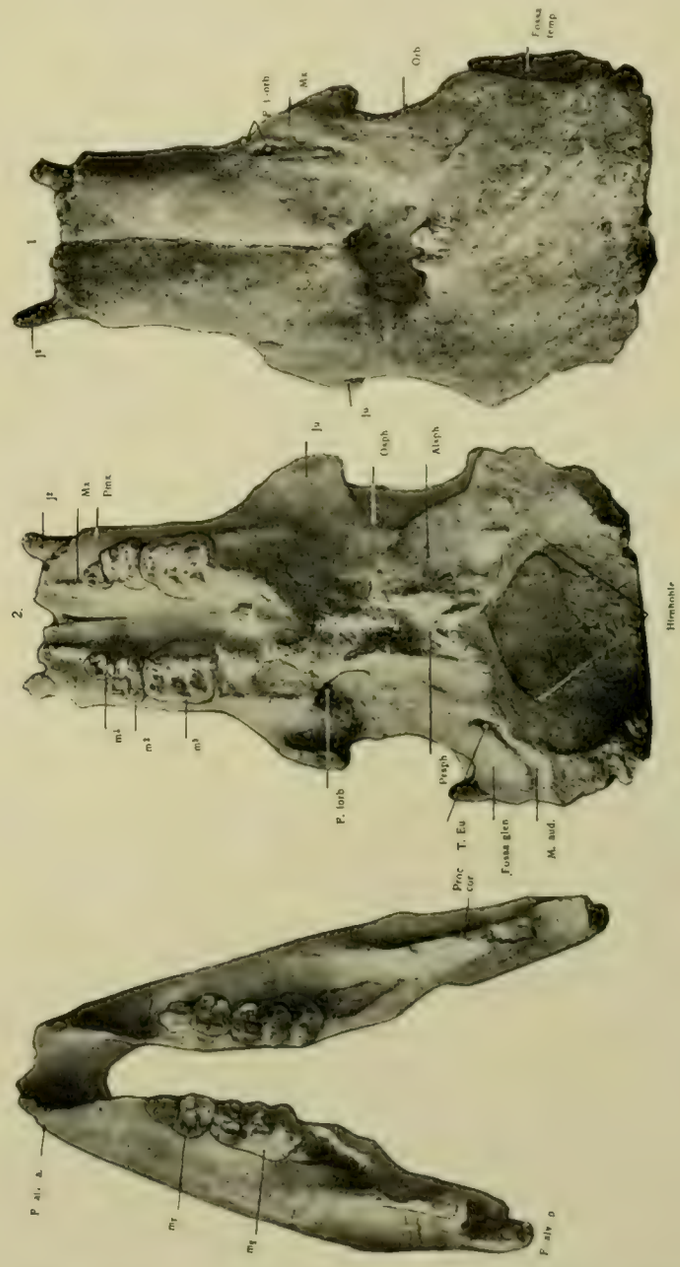


Fig. 208. Referred juvenile cranium and milk dentition of *Trilophodon* (*Choerolophodon*) *pentelicus* from the island of Samos. After Schlesinger, 1922, Taf. xx, figs. 1, 2, and Taf. xxi, fig. 1, one-sixth natural size. The milk teeth (indicated in abbreviations as M1-M3) are: Dp^2-Dp_2, Dp^3-Dp_3, Dp^4-Dp_4; Di^2 is also present.

Observe the chœrodont and tuberculate condition of the surfaces of the grinding teeth compared with detailed drawing of grinders from the same geologic horizon of Samos (Amer. Mus. 20703), figure 207 opposite.

beiden Hälften streng ein; beim zweiten ist der posttrite Halbteil stark nach hinten verschoben. Dadurch entsteht die seinerzeit oft besprochene eigenartige Alternation, die für m^2 dieser Art sehr bezeichnend ist. Der m^3 [Dp^4] zeigt in typischer Entfaltung deutlich das hervorstechendste Merkmal der *Pentelici*-Molaren: die **W**-förmige Anordnung der prätriten Haupthöcker, welche durch die bedeutende Vordrängung der Sperrpfeiler entsteht. Der Talon ist hinten und vorne kräftig. Zement findet sich als typische Überlagerung des Schmelzes, wie immer bei dieser Art. . . . Die Molaren sind wieder völlig typisch. Erster Milchzahn ist der m_2. Sein höchst eigenartiger Bau kehrt auch an diesem Rest charakteristisch wieder. An das lange, gequetschte Vorderjoch, welches aus zwei hintereinander gelegenen Höckern besteht, schliesst sich das zweite, aus nebengestellten Pfeilern zusammengesetzte. Ihm folgt der mächtige, aber eng an das 2. Joch gedrängte Talon mit seiner unregelmässigen Bildung. Der m_3 ist typisch dreijochig, lang und schmal und zeigt prätriterseits wieder das sehr bezeichnende ausgezogene '**W**'."

Incisive Tusks (Schlesinger, 1922, pp. 153, 154):—"Die choerodonte Reihe (*M. Pentelici*) zeigt zwar ein für die I^2 sehr bezeichnendes Merkmal, die Krümmung normal auf die grössere Querschnittachse, doch sind von dieser Art ausgewachsene Formen zu wenig bekannt, als dass man mit Sicherheit auf die Verhältnisse der I^2 dieser schliessen könnte. Wir werden also gut tun, auch bei dieser Reihe, von welcher für unsere Gegenden bloss *M. Pentelici* in Betracht kommt, hinsichtlich der Bestimmung auf Grund von oberen Stosszahnresten sehr vorsichtig zu sein."

Juvenile Palate from Samos (Amer. Mus. 20703)

The anterior portion of a young cranium (Fig. 207), part of the Samos collection made by Barnum Brown in the year 1924, reveals characters of the three superior intermediate molars, Dp^3-M^1, in which irregular conules are seen blocking the valleys; there is also an irregular disposition of the cones, quite distinct from the rounded and regular disposition of the cones and conelets in *Trilophodon angustidens* of Simorre (Figs. 190, 191). These intermediate molars do not distinguish *Choerolophodon* as a subgeneric or side branch of the *Trilophodon* phylum. The fourth superior milk premolar, Dp^4 (Fig. 205), is closely comparable to that of *Trilophodon pandionis* (Figs. 209, 210) of the Middle Miocene of Sind, and clearly distinguishes this animal from any member of the *Tetralophodon* phylum.

These milk premolars should be compared with those shown in figures 176 (p. 234), and 177 (p. 235). Our present conclusion, from the evidence furnished by the juvenile specimens as figured above from Pikermi and Samos, is that they represent a Lower Pliocene stage of the genus *Trilophodon* Falconer. Consequently *Mastodon pentelicus* Gaudry should be written *Trilophodon pentelicus*, the subgenus *Choerolophodon* Schlesinger being a synonym of the genus *Trilophodon* Falconer.

9. ASIATIC SPECIES OF TRILOPHODON, CHIEFLY OF MIDDLE AND LOWER MIOCENE AGE

For Geologic Horizons and Faunal Life Zones of India, see Chapter X, Figures 413 and 414, Pages 448 and 449

Previous to the time that Pilgrim joined the Indian Survey and worked in the field, all fossils in the collections of the British Museum and Calcutta Museum were designated simply as from the Siwalik Hills, from Sind, and from other general localities. Pilgrim's field work (1905–1926) enabled him to make many new geologic subdivisions, and it is only by referring type specimens in the British and Calcutta Museums to *topotypes* found or located by Pilgrim and his associates, that we are able to establish the horizons of the original type specimens of Sind, the northern Punjab, and Baluchistan, as follows:

Larkana District of Sind, India, 'Lower Manchhar' stage, Middle Miocene:
Type of *Mastodon* (*Trilophodon*) *pandionis* Falconer, 1857.

From near Kamlial, Salt Range, northern Punjab, India, Kamlial horizon, Middle Miocene (= 'Lower Manchhar' stage of Sind, India):
Type of *Mastodon* (*Trilophodon*) *angustidens* var. *palæindicus* Lydekker, 1884.

Gaj horizon of Kumbhi, 'Bugti beds,' Bugti Hills, Baluchistan, Lower Miocene:
Type of *Hemimastodon crepusculi* Pilgrim, 1912; referred by Osborn to the Suina.
Type of *Trilophodon cooperi* Osborn (first referred by Forster Cooper to *Bunolophodon angustidens* Lyd.).

Chur-Lando horizon of the Bugti Hills, Baluchistan, Oligocene:
Type of *Baluchitherium osborni*. No Mastodonts or Deinotheres.

Mastodon (*Trilophodon*) *angustidens* var. *palæindicus* Lyd., type, from the 'Lower Manchhars' (Fig. 211), is only slightly more progressive than the molar referred by Forster Cooper to *Bunolophodon angustidens* [= *Trilophodon cooperi* Osb., type (Fig. 222)]; both exhibit four plus ridge-crests, with two cones on the rudimentary pentalophid, and thus correspond in character with the *Trilophodon angustidens* of Simorre (Fig. 195).

MASTODON PANDIONIS.—Hopwood (letter, Feb. 10, 1932) differs from all previous authors; he considers that: (1) The type (Fig. 210) of *Mastodon pandionis* Falc. is a true *Trilophodon*, but that most of the specimens referred by Lydekker are "referable to one or other of the species of *Synconolophus*" Osborn, 1929.

(2) *Mastodon angustidens* var. *palæindicus* Lyd., 1884, is not related to *M. angustidens* at all, but is also an early term of the *Synconolophus* lineage.

(3) *Hemimastodon crepusculi* Pilg., 1912 (Fig. 216), has affinities with *Palæomastodon* Andrews, 1901, of the Fayûm, N. Africa, and *Trilophodon cooperi* Osb. from Baluchistan, named after Forster Cooper, and is related to, but more primitive than, the true *M. angustidens* of France.

Hopwood regards the Gaj horizon of Baluchistan as slightly older than the Burdigalian of France and as containing mastodonts which wandered westward into the Sables de l'Orléanais, the true Lower Miocene of France. The beds of the Gaj horizon near Kumbhi (Lower Miocene) are about twelve miles southwest of the Bugti beds near Dera Bugti (Lower Miocene). See Pilgrim, 1912, Pl. XXXI.

Trilophodon pandionis Falconer, 1857

Figures 79, 209, and 210

Larkana District of Sind, India, Lower Manchhar, Middle Miocene (=Kamlial horizon of the Punjab). See figures 413 and 414 of the present Memoir verified by Pilgrim.

Compare *Mastodon* (*Trilophodon*) *angustidens* var. *palæindicus* Lydekker, 1884, from near Kamlial, northern Punjab, India.

Syn.: *Mastodon Andaranus* Falc., 1868.

Hopwood (letter, Feb. 10, 1932) observes that the *type* tooth is far too large (ap. 102 mm., tr. 60 mm.) for a Dp^4 and that it is more likely an M^2 than an M^1; that the Larkana District of Sind is the probable locality. Most of the *referred* specimens which Lydekker (1886) described as *M. pandionis* belong rather to one or other of the species of *Synconolophus* [cf. Figs. 623, 625, l.M^2 of *S. ptychodus*].

Fig. 7

Fig. 6

Fig. 209

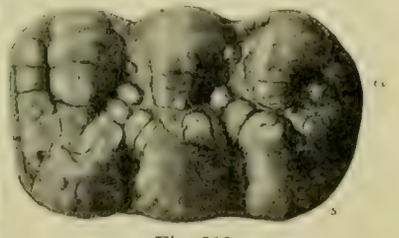


Fig. 210

TYPE SUPERIOR MOLAR (L.Dp^4) OF TRILOPHODON PANDIONIS Falc.

Fig. 209. (Falconer) Type of *Mastodon* (*Trilophodon*) *pandionis* Falc., 1857, two-fifths natural size. From the Larkana District, Sind, India, Lower Manchhar, Middle Miocene. Brit. Mus. 40818. After Falconer, 1868, Vol. I, Pl. XXXIV, figs. 6, 7: "Two views, in plan and profile, of the antepenultimate upper left molar [M^1] of *Mastodon* (*Trilophodon*) *Pandionis*. The specimen thus identified in Dr. Falconer's handwriting was found in his private collection, and has been deposited in the Palæontological Gallery of the British Museum." Lydekker (1885, p. 99): "The original is probably from Sind . . . and is figured in the 'Pal. Ind.,' ser. 10., vol. iii., pl. v., fig. 5."

Fig. 210. (Lydekker). Type of *Mastodon* (*Trilophodon*) *pandionis* Falc., 1857 (M^1, *fide* Pilgrim, 1913, p. 292). After Lydekker, 1884.2, Pl. v, fig. 5. Reproduced as a superior figure to that of Falconer (1868, Vol. I, Pl. XXXIV, figs. 6, 7). Reduced to one-half natural size.

Falconer's first mention of this species (1857, p. 317) is as follows: "The most complex crowns are presented in the Trilophodons by *M.* (*Triloph.*) *Pandionis* (an Indian fossil species recently discovered and as yet undescribed)." The following is his definition of *Trilophodon* (*op. cit.*, p. 316): "Subgenus 1. TRILOPHODON.—Dentium molarium 3, utrinque intermediorum coronis colliculis 3." In this same paper (table opp. p. 319) he ranges this animal under the subgenus *Trilophodon* as follows: "7. M. (Triloph.) Pandionis . . . Pliocene? . . . Southern India . . . Imperfectly known, but very distinct as a species; is the only Indian *Trilophodon*." Consequently *Mastodon* (*Trilophodon*) *pandionis* Falc., 1857, is the first species of *Trilophodon* described from India.

If Lydekker (1885, p. 99) is correct in attributing the type specimen (Figs. 209, 210) to Sind, it is probable that it came from the Larkana District, of Middle Miocene age, and should be compared with the corresponding grinders of *Trilophodon angustidens* from Sansan (Fig. 196 of the present Memoir); the species *M.* (*Triloph.*) *Pandionis* Falconer, 1857, may preoccupy the species *M.* [=*Trilophodon*] *angustidens* var. *palæindicus* Lydekker.

Osborn (1935) compares Falconer's type (Figs. 209, 210) of *M. pandionis* (ap. 102 mm., tr. 60 mm.) with the Dp^4 of Gaudry's *M. pentelici* and of *M. angustidens* (Fig. 196); also with Osborn's Dp^4 (ap. 74 mm., tr. 52 mm.) or M^1 (ap. 91 mm., tr. 62 mm.) of *Trilophodon* (*Choer.*) *pentelicus* (Fig. 207) of Samos. In Osborn's opinion Falconer's type is a fourth left superior deciduous premolar, l.Dp^4; it lacks 'central conules.'

M. (*Triloph.*) *Pandionis* Falconer. "On the Species of Mastodon and Elephant occurring in the fossil state in Great Britain. Part I. Mastodon." Quart. Journ. Geol. Soc. London, XIII, 1857, p. 317, table opp. p. 319. TYPE.—(Falconer, 1868, Vol. I, p. 124): "The principal piece is a penultimate molar, upper jaw, left side [l. Dp^4], so determined from comparison with a germ specimen from M. Lartet of an antepenultimate." HORIZON AND LOCALITY.—[Error] Deccan, India, see Falconer, 1868, Vol. I, p. 124. Lydekker (1884.2, p. 29) corrects Falconer and states

regarding the type (Brit. Mus. 40818) that "in Sind the remains of *M. pandionis* occur in the lower Siwaliks; and that no strata equivalent to the Siwaliks are known in southern India." On page 29 also occurs the following footnote: "It is just possible that the confusion may have arisen in the following manner:—It was known that Col. Sykes obtained a large collection of mesozoic fossils from the Deccan, and if the mastodon remains were not fully labelled, nothing is more likely than that they should have been assigned to the same locality." Again Lydekker (1886.1, p. 38) gives the type locality as "the Lower Siwaliks of Sind, India, or the regions to the north." Probably the correct horizon and locality are as follows: Lower Manchhar, Middle Miocene, Larkana District, Sind. TYPE FIGURE.—Falconer, 1868, Vol. I, Pl. XXXIV, figs. 6 and 7.

TYPE DESCRIPTION.—(Falconer, 1868, I, p. 124): "(Extracted from Note-Book: 24th December, 1856.) No. 1.—The principal piece is a penultimate molar, upper jaw, left side; so determined from comparison with a germ specimen from M. Lartet of an antepenultimate. The crown of the tooth is perfectly entire, the front ridge alone being a little touched by wear on the inner side; but the fangs and base of the tooth are broken off right across on a line with the termination of the enamel shell. It exhibits three well-defined ridges, with a thick strong front talon, and a hind talon confluent with the last ridge. It is a true and unmistakeable *Trilophodon*—the only one yet yielded by India, and very different in its crown characters from all the Sewalik, Ava, or other fossil Mastodons of the East." There follows a long and very detailed description beginning (p. 124) "The general form of the crown resembles very strongly that of *Triloph. angustidens*," and ending (p. 125) "The posterior talon consists of a cluster of indistinct confluent tubercles thrown off from the posterior part of the inner tubercle of the last ridge, and so adpressed to the ridge that it does not yield the defined and separate appearance seen in the talon of *Triloph. angustidens*. After a little wear, the posterior talon would be involved in the disc of detrition of the last ridge."

This detailed description leaves no manner of doubt that figure 209 above (Brit. Mus. 40818) is Falconer's type of *Mastodon* (*Trilophodon*) *pandionis*.

LYDEKKER, (1884–1886).—This "true and unmistakeable *Trilophodon*" of Falconer was first regarded by Lydekker (1884.3, p. 153) as an ancestor of *Mastodon perimensis* and *M. sivalensis*. Subsequently (1886.1, pp. 37, 38) it was compared by Lydekker with the type milk dentition of *M. pentelicus* Gaudry: "The third milk-molars provisionally referred to it are more complex than is usually the case with trilophodont species, and in this respect agree with those of *M. pentelici;* . . . It differs from $\frac{mm.4}{}$ of *M. pentelici* by its taller and more nearly vertical ridges and by the greater blocking of the valleys, in consequence of which the crown surface of the first two inner columns forms a distinct **W**."

Osborn, 1924: This deciduous type (Brit. Mus. 40818), considered by Falconer as a "true and unmistakeable *Trilophodon*," was rightly compared by Lydekker (1886.1, p. 37) with the fourth deciduous premolar of *Mastodon pentelicus* Gaudry. On the other hand, Pilgrim (1913, p. 292) first observed: "The type of *Tetrabelodon pandionis* is an upper first molar, of which the locality is not precisely known but which Lydekker considers with a fair show of probability to have come from Sind."

Trilophodon palæindicus Lydekker, 1884

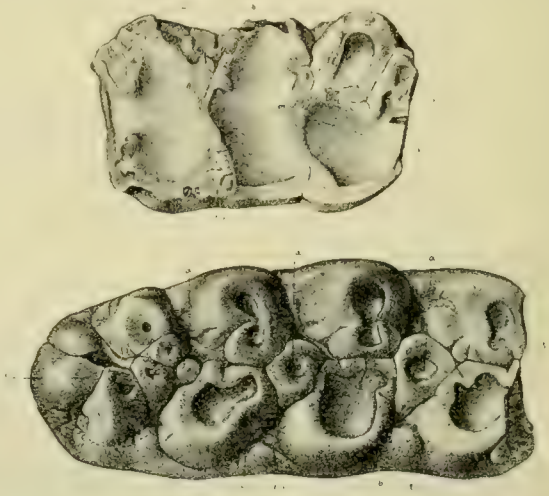
Figures 211, 220, 222, 300

From near Kamlial, Salt Range, northern Punjab, India, Kamlial horizon, Middle Miocene (='Lower Manchhar' stage of Sind).

Hopwood (letter, Mar. 5, 1929) regards the species *Mastodon angustidens* var. *palæindicus* as a synonym of *M. pandionis;* he suggests (letter, Feb. 10, 1932) that it is "the earliest term of the *Synconolophus* lineage."

Osborn (1932) observes that the type M_3 of *Mastodon palæindicus* is more primitive, far simpler, less chœrodont, less dislocated, less warped, than the types of *Synconolophus ptychodus* (Fig. 623), of *Syn. hasnoti* (Fig. 622), and of *Syn. corrugatus* (Fig. 622). It exhibits rudiments of double internal trefoils, lacking in *Syn. hasnoti;* it therefore resembles *Tetralophodon falconeri* (Fig. 309) and *T. longirostris* (Fig. 315) more closely than any known species of *Synconolophus*. The ridge-crests are less warped than in *Anancus arvernensis* (Fig. 600). It agrees with the progressive species *Trilophodon chinjiensis* (Fig. 218 A2) of the Lower Chinji horizon; it is much more progressive than the typical *T. angustidens*.

Osborn (1935) determines Lydekker's '*Mastodon*' *palæindicus* as probably synonymous with Falconer's '*M.*' (*Tril.*) *pandionis*, of Middle Miocene age; he also regards *Trilophodon palæindicus* as a true Longirostrine, not to be confused with the Brevirostrine *Synconolophus*.



TRILOPHODON PALÆINDICUS TYPE. FROM NEAR KAMLIAL, PUNJAB, MIDDLE MIOCENE = LOWER MANCHHAR STAGE OF SIND. SEE ALSO PAGES 270, 271

Fig. 211. Type right M_3 of *Mastodon* (*Trilophodon*) *angustidens* var. *palæindicus* Lydekker, 1884, Pl. IV, fig. 3, one-half natural size. From near Kamlial, northern Punjab, India, Middle Miocene. Cast Amer. Mus. 9905, exchange Calcutta Museum. Observe that the third inferior type molar of *T. angustidens palæindicus* is much more progressive than the referred inferior molar (Fig. 195) of *T. angustidens* of the Middle Miocene of Simorre. (Lydekker, 1885, pp. 101, 102): M^2, Ind. Mus. A.425, in association with the type right M_3, Ind. Mus. A.426, Pl. IV, fig. 3. Central conules, *a*,*a*,*a*.

Compare new type figure (Fig. 222, p. 276).

TYPE.—Lydekker's type (1884.2, Pl. IV, fig. 3) of this species, *palæindicus*, is a third right lower true molar in the Indian Museum of Calcutta (A.426), associated with a second left upper true molar (*op. cit.*, Pl. IV, fig. 2), Ind. Mus. A.425. Lydekker concludes a

very long description (*op. cit.*, p. 19, "Species 1: *Mastodon* (*Trilophodon*) *angustidens*, Cuv. Var. *palæindicus*, nobis") and comparison with *M. angustidens* (pp. 20, 21) and with other Indian specimens (pp. 22–27), finally observing (p. 28): "*Summary.*—As the result of the foregoing comparisons it appears that the present species of mastodon is specifically distinct from both the other Siwalik trilophodons; but that it agrees so closely with the European *M. angustidens* that there seems no alternative but to refer it to the same species. Since, however, there appears a tendency in the Indian form to a slightly more complex structure of the molars, and to a greater curvature of the borders of the crown of $\frac{}{m.3}$, it may be advisable to mark this local variation by distinguishing the Indian race under the name of *M. angustidens*, var. *palæindicus*. [Footnote: 'The term *indicus* would have been preferable, but as the writer is persuaded that the elephants and mastodons will eventually have to be united in one genus, it might lead to confusion.']."

Geologic Level.—Lydekker (1884.2, p. 1) states that "the whole of the specimens . . . forming the subject of the present memoir were collected in 1882 by Mr. W. T. Blanford from the lower Siwaliks, or Manchhars, of the extreme western side of India; the two most important localities being Gandoi, in the Bugti Hills, north of Jacobabad, in Sind; and Dera Bugti, on the north-eastern frontier of Balúchistán." Lydekker gives Dera Bugti as the type locality of his '*Mastodon*' *palæindicus*, but according to Pilgrim it is from the Lower Manchhar zone, Middle Miocene. As described (1922) by Forster Cooper[1] in his "Miocene Proboscidia from Baluchistan," his numerous referred specimens are also from 'Dera Bugti, Baluchistan,' but they are probably of Lower Miocene age. Below the 'Bugti' are the 'Chur-Lando' beds, Upper Oligocene, containing *Baluchitherium osborni* (Fig. 413).

Mastodon (*Trilophodon*) *angustidens*, Cuv. var. *palæindicus* Lydekker, 1884. "Additional Siwalik Perissodactyla & Proboscidia." Pal. Indica, Ser. X, Vol. III, pp. 19–29. Type.—A third lower molar of the right side, r.M_3. Original in Indian Museum (No. A.426); cast Amer. Mus. 9905; in association with this third right lower molar was a second upper molar (Ind. Mus. A.425). Horizon and Locality.—From near Kamlial, Salt Range, northern Punjab, India. Kamlial horizon, Middle Miocene. Type Figure.—Lydekker, 1884.2, Pl. iv, fig. 3; associated molar, fig. 2.

Type Description.—(Lydekker, 1884.2, pp. 19–21): "This tooth [third lower molar of the right side, Pl. iv, fig. 3], which is in an intermediate stage of wear, was associated with the second upper true molar represented in figure 2 of the same plate; it carries four transverse ridges and a talon (*ta*); from which circumstance, together with the shape of the crown, and the concave form of the worn masticating surface, it is evidently the last lower molar of a trilophodont mastodon. . . . Compared with the last lower molar of *M. angustidens* the present specimen agrees very closely. A tooth of that species figured by H. von Meyer [Footnote: 'Paläontographica, vol. XVII., pl. vii., figs. 3 and 4.'] is of precisely the same size, and has the same general contour of the crown, with the exception that the borders of the crown are less curved: and in other European specimens . . . these borders are still less curved. The arrangement of the ridges, and the form of the transverse valleys, is exactly the same in the two; and there are the same blunt tubercles at the outer extremities of the transverse valleys. The hind talon of the European tooth is, however, more detached; and consists of only one column. The most important difference between the two teeth consists in the greater development of the posterior accessory columns (*a*) in the Indian tooth. In the European tooth these are not larger than the anterior accessory columns (*b*), and do not extend on the outer side of the median longitudinal fissure; this causes the blocking of the middle of the transverse valleys to be less complete than in the Indian tooth. . . . It appears, therefore, that the differences between the present specimen and the last lower molar of *M. angustidens* are scarcely, if at all, greater than those occurring between different European specimens of the latter; and it thus seems probable that at the most they should be reckoned merely as of varietal value. The greater development of the accessory columns in the Indian tooth is a step from the typical form of *M. angustidens* towards the more complex tooth of *M. pandionis*."

Fig. 5.

Mastodon angustidens, var. *palæindicus*.—The fourth left lower milk-molar; from the Lower Siwaliks of Dera Búgti, north-west frontier of India. ½. Indian Museum, Calcutta, No. A 422.

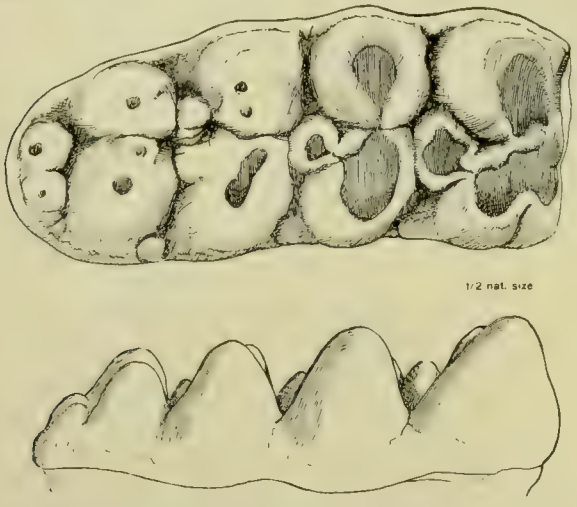
Fig. 212. Referred lower molar (l. M_2) of *Trilophodon palæindicus* from near Kamlial, northern Punjab, India, Lower Manchhar, Middle Miocene. After Lydekker, 1886, p. 33, fig. 5. Natural size.

History of Opinion.—The type of this important subspecies from near Kamlial, northern Punjab, is regarded by Lydekker as very close to *Trilophodon angustidens* and by Cooper (1922) as a variation of *T. angustidens*. From Lydekker's type r.M_3 (Fig. 211), there can be no doubt that *Mastodon angustidens* var. *palæindicus* belongs in the true *Trilophodon* phylum. The history of this specimen is as follows:

Forster Cooper (1915–1923).—In 1915, p. 410, this author wrote as follows[1]: "Pilgrim [Footnote: 'Pal. Ind. n.s. vol. iv. memoir 2.'] has suggested that the teeth described by Lydekker [Footnote: 'Pal. Ind. (10) vol. iii. pl. iv. fig. 3.'] from this locality as *Tetrabelodon angustidens*, var. *palæindicus*, really belong to *Hemimastodon*. That this surmise is correct is proved by the fact that the third lower molar of the first jaw mentioned above is the same

[1]The reader is warned that pages 266–271 were written from the older texts of Lydekker and Forster Cooper, before the primitive *Trilophodon cooperi* Osb. (= *Bunolophodon angustidens* ref. of Cooper), of the Bugti beds, was clearly distinguished from the more recent and more progressive *T. palæindicus* Lyd. of the Kamlial, Salt Range, northern Punjab, as figured (Figs. 222, 223) and described below under *Trilophodon cooperi* Osb. (pp. 275–278).

as the tooth figured by Lydekker . . . as belonging to the variety of *T. angustidens* [var. *palæindicus*]." Forster Cooper wrote in a letter, October 4, 1923: "I cannot see in any of these teeth much promise of a future *arvernensis-anancus* pattern even in embryo. Incidentally I am not clear as to the mechanics by which this peculiar interdigitation of the ridges arose (has the acquisition of a curvature of the tooth anything to do with it or is it the growth of the intermediate cusp, or both acting together?), but I notice that this alternation of ridges is most marked at the front end of the teeth in question and least of all at the posterior end and talon [as, e.g., Schlesinger, Geol. Hung., Tome II, fasc. 1, plate IX, fig. 6]. In the Indian forms the front ridges are very straight and the hinder ones curved; just the reverse, and even then not so as to suggest alternation."



TRILOPHODON COOPERI OF THE BUGTI HORIZON, LOWER MIOCENE, BUGTI HILLS, BALUCHISTAN

After drawings sent to the present author by C. Forster Cooper
One-half natural size

Fig. 213. (Upper) *Trilophodon cooperi*. Referred third right lower molar, r.M_3, a surface collected specimen from near Dera Bugti, Baluchistan, Lower Miocene, in the British Museum. Cast Amer. Mus. 27014. Compare "*Bunolophodon angustidens*," Cooper, 1922, text fig. 4.

(Lower) *Trilophodon cooperi*. A third right lower molar, r.M_3, referred by Cooper to "*Bunolophodon angustidens*," 1922, Pl. II, fig. 1, also text fig. 3, in the British Museum. Cast Amer. Mus. 27013. Compare *Trilophodon cooperi* type (Fig. 222, p. 276).

TRILOPHODON COOPERI REFERRED FROM THE LOWER MIOCENE

Lower Miocene, Bugti Hills, near Dera Bugti, and Gaj horizon, Bugti Hills, near Kumbhi, Baluchistan.

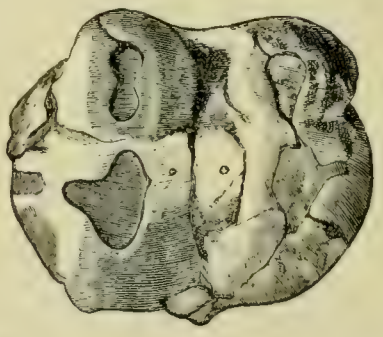
Osborn, 1932: The referred Bugti Hills molar, M_3 (Fig. 213), closely resembles in form and size the typical '*Mastodon*' *angustidens* of the Middle Miocene of Simorre (Fig. 195); it is much simpler and more primitive than the type of '*M.*' *palæindicus* (Fig. 211). The presence of an ancestral stage of '*M.*' *angustidens* in the Bugti beds horizon near Dera Bugti is confirmed (Cooper, 1922) in a palate (Brit. Mus. M12179, cast Amer. Mus. 5211) and jaw (Brit. Mus. M12181, cast Amer. Mus. 5205) in the Forster Cooper Coll. of the British Museum. This stage has been designated by the specific name *Trilophodon cooperi*, a stage which seems to be quite similar to *Trilophodon inopinatus* of the Jilančik horizon of Turgai (Fig. 224A, B, C, p. 278, below).

Hopwood (letter, Feb. 10, 1932) regards the so-called *Trilophodon angustidens* from the Gaj (Bugti beds) of Baluchistan as of slightly greater geologic age than the Sables de l'Orléanais type of the Burdigalian of France.

COMPARISON OF LOWER AND MIDDLE MIOCENE TRILOPHODONTS

Lydekker, Cooper, Osborn, 1886–1915–1922-1935.—The presence in Miocene beds of a referred *Trilophodon* related to *T. angustidens* is indicated, however, in a molar from near Kamlial, northern Punjab, referred by Lydekker, (1886, p. 33, fig. 5 –our Fig. 212) to '*M.*' *palæindicus*, also in specimens subsequently described (1922) by C. Forster Cooper from the Bugti beds. As compared with figure 194, reproduced from Lydekker's Memoir of 1886, this referred *Trilophodon* tooth (Fig. 212) is probably a left lower

Fig. 6.



Mastodon angustidens, var. *palæindicus*.—The first and second ridges of the first right lower true molar, in a half-worn condition; from the Lower Siwaliks of Sind or the regions to the north or west. ½. (From the 'Palæontologia Indica.')

Fig. 214. Referred superior molar fragment, r.M^1 (?), of *Trilophodon cooperi*, from near Dera Bugti, Bugti Hills, Baluchistan, Middle Miocene. After Lydekker, 1886, p. 34, fig. 6, natural size. Brit. Mus. 40788.

Compare this tetrabunodont fourth superior true premolar with (1) the fourth superior premolar type of *Mastodon* [=*Serridentinus*] *proavus* Cope (Fig. 363), with (2) the fourth superior premolar, P^4, of *Serridentinus serridens* (Fig. 390), also (3) with the tooth referred by Lydekker to (?) *Mastodon pandionis* (see Fig. 215 below).

Fig. 7.

? *Mastodon pandionis*.—The fourth right upper premolar; from the Lower Siwaliks of Dera Búgti, north-west frontier of India. ½. Indian Museum, Calcutta, No. A 432. (From the 'Palæontologia Indica.)

Fig. 215. Fourth right superior true premolar, P^4, natural size, of *Trilophodon cooperi*, erroneously referred by Lydekker to (?) *Mastodon pandionis*. From near Dera Bugti, Bugti Hills, Baluchistan, Middle Miocene. After Lydekker, 1886, p. 37, fig. 7.

molar, l.M_2. The index 58, however, is much lower than that in the typical M_2 from Simorre, namely, 65–68; in other words, this tooth is *relatively narrower* than the corresponding teeth of the typical *T. angustidens*. We would not venture, therefore, to determine its position without first examining the original specimen. Osborn observes also that the smooth surface of this tooth resembles the adult M_1 rather than the crenulated Dp^4 from Sansan; in other words, this Bugti animal is certainly related to *T. angustidens*, but the tooth is relatively narrower and consequently of a more progressive type. One other specimen (Fig. 214), referred by Lydekker to the species '*Mastodon*' *palæindicus*, appears to belong to *Trilophodon cooperi*.

C. Forster Cooper, 1915, 1922.—C. Forster Cooper (1915, 1922) describes the proboscidean remains he obtained during his two expeditions to the Lower Miocene deposits in the Gaj beds of Baluchistan. He regards all the specimens he found, after close comparison with those from Simorre and Sansan, as belonging to the same stage of evolution, namely, to *Trilophodon* (*Bunolophodon*) *angustidens;* he considers Lydekker's type specimen of var. *palæindicus*, from Kamlial, northern Punjab, as also belonging to the same species and not to *Anancus palæindicus* as Osborn had suggested. It is interesting to test this difference of opinion by the indices and by comparison side by side of Forster Cooper's excellent figures.

Breadth-length index of Lydekker's type of *Mastodon* [=*Trilophodon*] *angustidens* var. *palæindicus:*

M_3: length 148 mm., breadth 63 mm., index 43.

Breadth-length index of Forster Cooper's *Bunolophodon angustidens* [=*Trilophodon cooperi* Osb.]:

M_3: length 147 mm., breadth 63 mm., index 43.

This breadth-length index of the third lower molar of (*Bunolophodon*) *angustidens* from Dera Bugti is exactly the same as that in the average M_3 of the seven Simorre, Sansan, and Tournan specimens of *T. angustidens* in the Paris Museum. The breadth-length index in Lydekker's type of *T. angustidens palæindicus* is 43, which agrees with the Paris specimens from Simorre.

Osborn, 1923: The type tooth of *T. angustidens* var. *palæindicus* (Fig. 211) from near Kamlial and the teeth referred to the species *Trilophodon angustidens* do agree very closely in actual measurements and indices with the typical specimens from the Middle Miocene of Sansan and Simorre and demonstrate that the Bugti beds contain quite abundant representatives of the true *Trilophodon angustidens* phylum. As Forster Cooper concludes (1922, p. 620): "The teeth are the average size of *B. angustidens*. Whether they represent another form or are within the range of variation of the latter species cannot at present be told."

Osborn, 1935: The above teeth are redescribed as *Trilophodon cooperi* Osborn from the Bugti horizon (Figs. 213, 222, 223) and *Trilophodon palæindicus* Lydekker from the Kamlial horizon (Figs. 211, 212).

[Hemimastodon crepusculi Pilgrim, 1912=Suina]

Figure 216

Lower Miocene, Gaj zone of Kumbhi, Bugti Hills, Baluchistan.

Compare *Conohyus*, *Tetraconodon*, *Sivachœrus*, and *Propotamochœrus* (Pilgrim, "The Fossil Suidæ of India," 1926).

The type (Fig. 216) of *Tetrabelodon* (*Hemimastodon*) *crepusculi* Pilgrim, 1908, 1912, is probably a third left superior molar, l.M^3, of one of the Suoids, or of the piglike Artiodactyls or bunodont Anthracotheres.

The type is not clearly designated in the original type description cited below. In the second mention (Pilgrim, 1912, p. 17) we read: "The specimens, on which this species is founded, are two 3rd upper molars, embedded in very fragmentary maxillæ. Associated with them was found a portion of a lower molar, probably the 2nd. . . . [p. 18] The type specimen is figured in Pl. iv, fig. 5. Its narrowness behind, shows that it must be the last of the molar series. It consists of three transverse ridges and a minute talon." This figure is reproduced herewith in the present Memoir (Fig. 216).

Tetrabelodon crepusculi Pilgrim, 1908. "The Tertiary and Post-Tertiary Freshwater Deposits of Baluchistan and Sind with Notices of New Vertebrates." Rec. Geol. Surv. of India, Vol. XXXVII, Pt. 2, p. 157.

Type of Hemimastodon crepusculi [=Suina], Gaj of Kumbhi, Bugti Hills, Baluchistan, Lower Miocene

Fig. 216. Type of *Hemimastodon crepusculi* Pilgrim, 1912, Ind. Mus. A.446; M^3 described (Pilgrim, 1912, explanation of Pl. iv, fig. 5) as: "3rd left upper molar, surface view. From the Gaj of Kumbhi, Bugti Hills. (Ind. Mus., No. A 446.) Page 17." Natural size. This specimen compares exactly with the measurements given on page 21 of the same Memoir, namely, M^3, length 93 mm., breadth 62 mm.

Original Type Description of T. crepusculi.—(Pilgrim, *op. cit.*, 1908, p. 157): "The mastodon teeth contained in my collection are those of a trilophodont species, undoubtedly nearer to *Mastodon falconeri* Lyd. than to anything else. It differs unmistakeably from that species in the far more open nature of the valleys, which are not blocked by accessory columns, by the simpler talon and by the more prominent cingulum on all sides of the teeth. To this species is referred a maxilla with a small slightly worn tooth 58 mm. long preceded by a much worn tooth 34 mm. long and by an empty alveolus. I see no sign of premolars to succeed them, but all the same it is not unlikely that they are milk teeth, which from their size and general character they might well be."

Hemimastodon crepusculi Pilgrim, 1912, p. 17. "The Vertebrate Fauna of the Gaj Series in the Bugti Hills and the Punjab."

Pal. Indica, N.S., Vol. IV, Mem. 2, p. 17. TYPE.—Third left superior molar, l.M^3, Ind. Mus. A.446. HORIZON AND LOCALITY.—Lower Miocene; Gaj zone of Kumbhi, Bugti Hills, Baluchistan. TYPE FIGURE.—Pilgrim, 1912, Pl. IV, fig. 5. See also Pl. IV, figs. 6–9, and Pl. III, fig. 4.

FORSTER COOPER, 1922, p. 613.—*Hemimastodon* a Synonym. "It may be stated at this point that no part of the material in the present collection gives any evidence in support of the genus *Hemimastodon* [Footnote referring to Pilgrim, 'Palæontologia Indica,' N.S., Vol. IV, Pt. 2, p. 17 (1912).], which was originally described from specimens from the same beds in Baluchistan. . . . If Pilgrim's specimen be an entire one, there remain alternative explanations. Either it is an abnormal specimen, or Pilgrim was correct in making a generic distinction for it and keeping it apart from the genus *Bunolophodon*. In neither case is there any proof for or against his view, except the negative evidence of two seasons' collecting over the same ground, which has produced nothing to confirm the genus *Hemimastodon*, while the more ordinary variations of *Bunolophodon angustidens* occurred in fair quantity."

SECOND DESCRIPTION OF H. CREPUSCULI (PILGRIM, 1912, p. 18).—This is a very full and detailed description of the type third superior molar reproduced herewith (Fig. 216).

4 ($\frac{1}{1}$)

REFERRED LEFT Dp^4 OF TRILOPHODON SP. OF THE GAJ

Fig. 217. An l.Dp^4 referred by Pilgrim to *Hemimastodon crepusculi*, after Pilgrim, 1912, Pl. III, fig. 4: "The 3rd left upper milk molar. From the Gaj of Kumbhi, Bugti Hills (Ind. Mus., No. A 449). Page 20." Natural size.

Osborn (1927) accepts the opinion of Forster Cooper and of Schlesinger (1917, p. 48) and regards this tooth as a fourth superior milk premolar, Dp^4, of the left side. We may therefore compare this milk tooth of *Trilophodon* sp. of the Gaj with our figure 196 above reproduced from Gaudry's "Les Enchainements du Monde Animal" of 1878, Fig. 239, a fourth superior milk molar of *Mastodon angustidens;* the proportions are not quite the same, the *M. angustidens* tooth, Dp^4, of Sansan, being relatively more elongate than the Dp^4 of the present figure.

Referred by Pilgrim to the same species from the Gaj of Kumbhi, Bugti Hills, are specimens figured in Pl. IV, figs. 6, 7, 8, 8a, and 9, namely, a right inferior molar, r.M$_2$ (Fig. 6), a right inferior premolar, r.P$_4$ (Fig. 7), a right inferior premolar, r.P$_3$ (Figs. 8, 8a), and two superior milk molars, Dp^3, Dp^4 (Fig. 9), all natural size. See also Pl. III, fig. 4, showing a left superior milk molar, Dp^4 (Fig. 217 of the present Memoir). From the same locality, "Gaj of Kumbhi, Bugti Hills," occur two specimens of *Deinotherium indicum* var. *gajense*. Also two specimens from the Gaj of Chur-Lando,[1] Bugti Hills, all figured on Plate IV.

In Pilgrim's full description of the type and referred specimens (1912, pp. 18, 19, 20) he describes in detail these superior and inferior molar and premolar teeth, and concludes (pp. 20, 21): "*Remarks.*—It is clear that the simplicity of structure of the teeth of this species distinguishes it from all known species of *Tetrabelodon* [*Trilophodon*] and it is unnecessary to institute more minute comparisons. It approaches *Palæomastodon* in certain respects, but is less primitively constituted. It seems necessary to make it the type of a new genus, which is at an evolutionary stage midway between *Palæomastodon* and *Tetrabelodon*."

Hopwood (letter, Feb. 10, 1932) supports Pilgrim's original reference, as follows: "The holotype is an upper molar which, as Pilgrim (1912, pp. 20, 21) has already pointed out, has affinities with *Palæomastodon*. . . . In this case it seems advisable to leave the species [*Hemimastodon crepusculi* Pilgrim] where the author originally placed it, for that is the position indicated by the resemblances in tooth structure."

Dr. W. D. Matthew writes (May 19, 1927): "I think you are very likely right in referring *Hemimastodon* type to the Suoids or the bunodont Anthracotheres. There is a big, almost bunodont Anthracothere in the Bugti fauna, M^3 unknown, but it would be pretty near to this size, and the characters are not far off."

Osborn, 1932: The triangular form and simple bunodont structure of the type (Fig. 216) when compared with the numerous excellent figures in Pilgrim's Memoir "The Fossil Suidæ of India," 1926, Pls. I–XX, appear remotely to relate *Hemimastodon crepusculi* to the section *Suina* of the piglike Artiodactyls; compare Pilgrim, *op. cit.*, Pl. II, fig. 11 (*Conohyus*), Pl. III, fig. 1*b* (*Tetraconodon*), fig. 3 (*Sivachœrus*), Pl. V (*Tetraconodon*), Pl. IX, fig. 3 (*Propotamochœrus*).

Trilophodon chinjiensis Pilgrim, 1913, Osborn, 1932

Figures 218, 222, 300

Mio-Pliocene, Lower Chinji, more recent than Simorre, Sansan, St. Gaudens, of the present Memoir. Holotype found two miles west of Chinji Bungalow, India.

Name only. *Tetrabelodon angustidens* var. *chinjiensis* Pilgrim, 1913. "The Correlation of the Siwaliks with Mammal Horizons of Europe." Rec. Geol. Surv., India, Vol. XLIII, Pt. IV, 1913, p. 316. The present author has been unable to find any type description or type figure by Pilgrim but takes great pleasure in publishing the accompanying figure (Fig. 218) and description dedicating the holotype (Amer. Mus. 19421) to his friend Dr. Guy E. Pilgrim.

ASSOCIATED FAUNA OF THE LOWER CHINJI.—(Cf. Pilgrim, 1913, p. 316, Fig. 413 of present Vol. I, also Geologic Table by Pilgrim and Osborn in Vol. II) *Tetrabelodon angustidens* var. *chinjiensis* type, [?]*Tetrabelodon* [= *Trilophodon*] *macrognathus* ref., *Deinotherium pentapotamiæ* type, *D. indicum* ref., *Serridentinus browni* type, *Aceratherium tetradactylum*, *A. perimense*, *Amphicyon giganteus*, *A. palæindicus*, *Teleoceras blanfordi* var., *Phyllotillon* sp., *Microbunodon silistrense*, *Hemimeryx pusillus*, *Hyotherium sindiense*, *Listriodon pentapotamiæ*, *Dorcabune anthracotheroides*, *Dorcatherium minus*, *Propalæomeryx sivalensis*.

SPECIFIC CHARACTERS.—Distinguished (Fig. 222) from the typical *Trilophodon angustidens* of Simorre and Sansan and from the *T. angustidens palæindicus* (Fig. 211) from near Kamlial, northern Punjab [='Lower Manchhar' stage of Sind], also from the *Trilophodon* sp. (Fig. 217) of the Gaj horizon of Kumbhi,

[1]CHUR-LANDO (Fig. 221, p. 275).—(Forster Cooper, letter, May 29, 1935): No specimens of *Deinotherium* or *Mastodon* occurred in the *Baluchitherium* bed at Chur-Lando. Beside *Baluchitherium* the bed yielded *Hemimeryx*, the advanced anthracotheres *Gelasmodon*, *Merycops*, rhinoceroses such as *Aceratherium abeli*, and lower jaws of a *Chiloiherium*.

Lower Miocene, by the presence of five and a half ridge-crests in the third inferior molars, as shown in the holotype (Fig. 218 A2, r.M_3); these grinders possess external trefoils and four central conules in the center of the crown, but a rudiment of an internal trefoil is observed in the proto- and metalophids, the two anterior ridge-crests. Consequently *Trilophodon chinjiensis* appears to be

Comparative Measurements in Millimeters

	Trilophodon angustidens gaillardi type Cast Amer. Mus. 21904	*Trilophodon chinjiensis* holotype Amer. Mus. 19421
Total length of jaw, condyles to tip of symphysis	1495	1435
Greatest width of jaw at terminal symphysis	incomplete	139
Total length of symphysis	831	782
Total length of r.M_3	190	178
Width of r.M_3	74	72
Breadth-length index of r.M_3	39	40

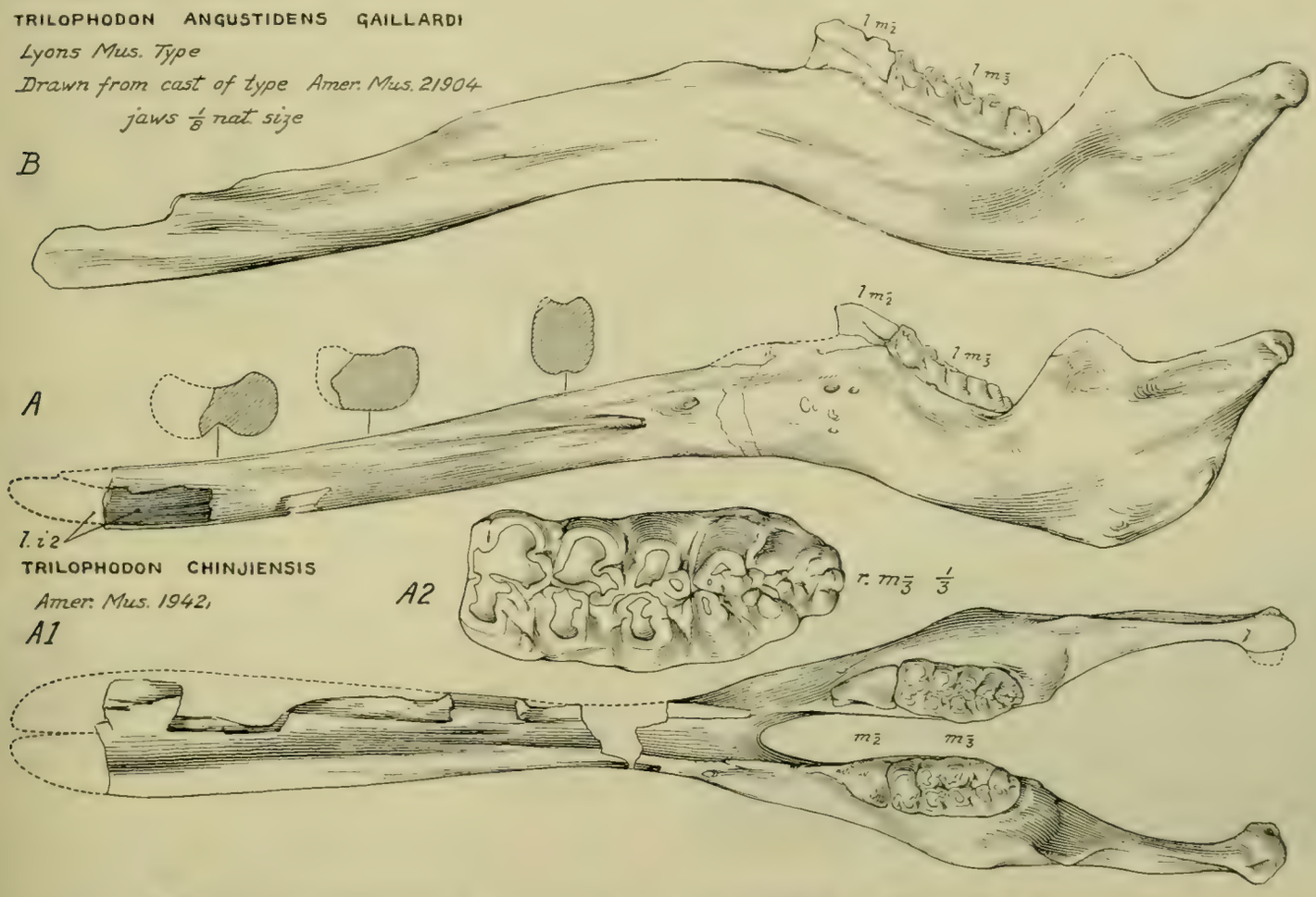


Fig. 218.—Type of Trilophodon angustidens gaillardi Osborn, 1929, and Holotype of Tetrabelodon [=Trilophodon] chinjiensis Pilgrim—Osborn

Holotype lower jaw (Amer. Mus. 19421) of *Trilophodon chinjiensis* Pilgrim—Osborn, 1913-1932 (A, A1, A2), Lower Chinji horizon, found two miles west of Chinji Bungalow, 600 feet above the base of the Lower Siwaliks, in the Salt Range of the Punjab. Also (B) type lower jaw of *Trilophodon angustidens gaillardi* Osborn in the Muséum des Sciences Naturelles de Lyon, from Villefranche d'Astarac (Gers), France, drawn from cast of type (Amer. Mus. 21904) kindly presented to the American Museum by Dr. Claude Gaillard.

Trilophodon chinjiensis.

A, Left external aspect showing portion of left inferior incisor, l.I_2; also three cross-sections of the symphysis. One-eighth natural size.

A1, Superior view of the same jaw and teeth, showing excessively elongated symphysis. One-eighth natural size.

A2, Third right inferior molar, r.M_3, with five and a half ridge-crests, prominent external trefoils, median conules, and rudiments of internal trefoils on proto- and metalophids. One-third natural size.

Compare figure 286D exhibiting the *hollow* incisors in section in comparison with (F) *Phiomia osborni:* these jaw sections prove that *Trilophodon chinjiensis* is quite distinct from the shovel-tusker *Amebelodon.*

Trilophodon angustidens gaillardi. Compare Fig. 198, p. 257.

B, Observe the three crested l.M_2 and the five and a half crested l.M_3. The scale of the jaw is one-eighth natural size. No incisive tusks or sockets observed in this mandible.

in the same five crested stage of inferior molar evolution as *T. angustidens gaillardi* from Villefranche d'Astarac, France (Fig. 198 and Fig. 218B) and as *Amebelodon (Tril.) hicksi* (Fig. 260).

Trilophodon macrognathus Pilgrim, 1913

Figures 219, 222, 300. See also figure 413

From near Chinji, Upper Chinji horizon of India = Mio-Pliocene.

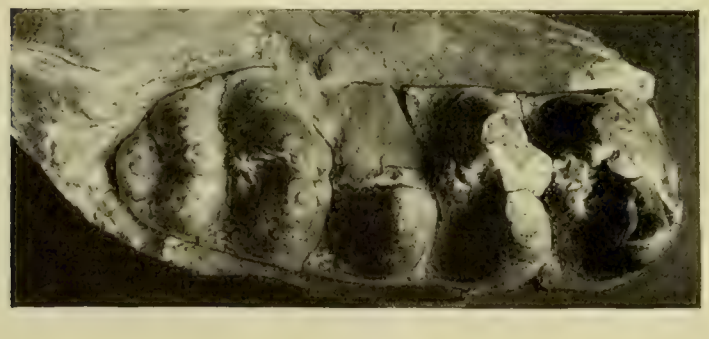
Trilophodon macrognathus is the uppermost trilophodont stage thus far discovered. It is replaced in the Jammu and Kangra, also in the Dhok Pathan levels, by progressive species of *Tetralophodon* and of *Synconolophus*, which doubtless will yield equally precise means of determining the higher geologic levels.

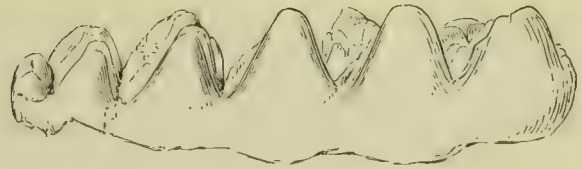
This species characterizes the Upper Chinji horizon as compared with *Trilophodon chinjiensis* of the Lower Chinji. According to Pilgrim's type description (1913) cited below, it is a true species of *Trilophodon* rather than of *Tetralophodon*, characterized by a much elongated symphysis and by three crested 'intermediate molars.'

(Hopwood, letter, Feb. 10, 1932): The holotype mandible, with rami fastened together, does not appear to leave room for more than a short rostrum. (Osborn, 1932): This statement of Hopwood is directly opposed to Pilgrim's statement (1913, p. 309) that the symphysis is very much more elongated than that of *Tetrabelodon* [= *Tetralophodon*] *punjabiensis*.

Osborn, 1926: The Upper Chinji is the type level of *Tetrabelodon* [= *Trilophodon*] *macrognathus* Pilgrim; it is therefore doubtful whether this species also occurs in the Lower Chinji, as indicated in Pilgrim's list (1913, p. 316) cited above (p. 272 of present Memoir).

Tetrabelodon macrognathus Pilgrim, 1913. "The Correlation of the Siwaliks with Mammal Horizons of Europe." Rec. Geol. Surv., India, Vol. XLIII, Pt. IV, p. 309. Type.—(*Op. cit.*, 1913, p. 309): "An interesting discovery in the Upper Chinjis of an absolutely perfect mandible of a species of *Tetrabelodon*." Ind. Mus. 692. Horizon and Locality.—Upper Chinji of India = Mio-Pliocene. (*Op. cit.*, 1913, p. 309): "Thus, the *Mastodon cautleyi-Stegodon* line is entirely absent even in its earliest stages; the *Mastodon* of the type of *arvernensis* has not yet appeared. On the other hand, species allied to *Tetrabelodon angustidens* [namely, *T. macrognathus* Pilgrim] are present. (*Op. cit.*, 1913, pp. 307, 308): "The precise level at which many of the Chinji fossils were found is uncertain." These beds contain *Hipparion* sp., *Palæoryx* sp., *Hyæna* sp., *Sivapithecus indicus*, also *Listriodon* sp., *Amphicyon* sp., *Deinotherium indicum*, *Dorcatherium minus*, *Hemimeryx pusillus*, *Protragocerus* sp., *Sus* sp. See figures 413, 414 of the present Volume I, also Correlation Table in Volume II.





Type of Trilophodon macrognathus

Fig. 219. Type of *Tetrabelodon macrognathus* Pilgrim, 1913, Upper Chinji horizon, Salt Range, India. A left third inferior molar, l.M_3, with 5½ ridge-crests, single external trefoils. After photograph kindly sent the author by Dr. Guy E. Pilgrim. Ind. Mus. 692. Length 236 mm. [225 mm. Fig. 300, p. 341], reduced to 79 mm., or one-third natural size.

This 5½ crested molar is much more progressive than the 4½ crested molar of *Trilophodon palæindicus* (Fig. 220).

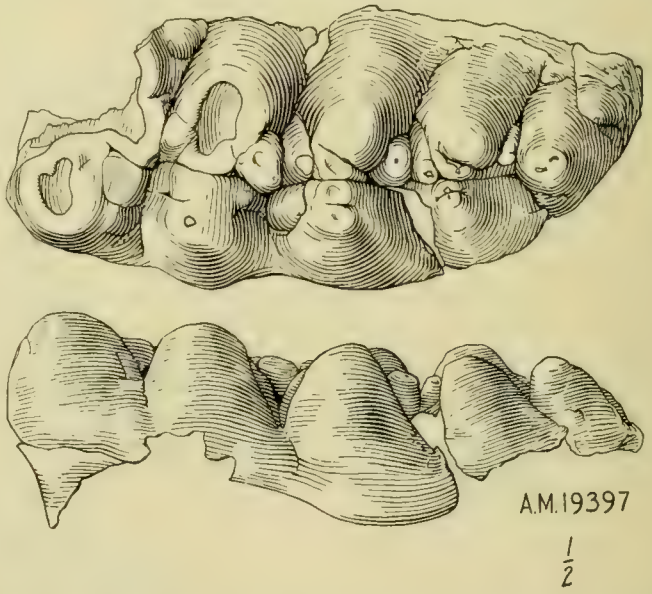


Fig. 220. Third right inferior molar, r.M_3, of *Trilophodon palæindicus* ref. (Amer. Mus. 19397), from near Nathot, India, Lower Middle Siwaliks, base of beds (Upper? Chinji horizon). Crown and external aspects; length 180 mm. One-half natural size. Observe the 4½+ ridge-crests, median external trefoil conelets and rudiments of internal trefoil conelets on the three anterior crests. Three central conules as in *T. palæindicus* type. See same molar in figure 222.

Type Description.—(Pilgrim, 1913, p. 309): "This species seems, as nearly as one can say, to have been the direct ancestor of the Middle Siwalik *Tetrabelodon punjabiensis*, the affinity of which with the European *T. longirostris* has already been noted (page 293). Possessing teeth of an exactly similar type, it differs from it by the rather more complicated talon in the last molar, by the greater prominence of the accessory columns, by the intermediate molars being trilophodont instead of tetralophodont, and finally by the very much more elongated symphysis. It is very remarkable to observe that the length of the symphysis is proportionately greater not only than that in *T. corrugatus* of Dhok Pathan but also than it is in *T. longirostris* and *T. angustidens*, which leads us to imagine that the Upper Chinji species, for which I propose the name of *Tetrabelodon macrognathus*, represents a very early stage of development."

MEASUREMENTS IN MILLIMETERS

	T. macrognathus	*T. chinjiensis*
Total length from articulation to tip of tusk	1530 mm.	
Total length from articulation to end of symphysis	1480	1435
Length of symphysis	810	782
Length of jaw behind symphysis	670	653
Length of last lower molar	236[225]	178

Trilophodon cooperi Osborn, 1932

Figures 222, 223, 300

From near Dera Bugti, Baluchistan. Bugti horizon, Lower Miocene.

Trilophodon cooperi Osborn, 1932. "Trilophodon cooperi, Sp. Nov., of Dera Bugti, Baluchistan," Amer. Mus. Novitates, No. 585, Nov. 15, 1932, pp. 1–6.

Forster Cooper described as '*Bunolophodon angustidens*' in his paper of 1922 on the "Miocene Proboscidia from Baluchistan" (pp. 610–620, figs. 1–7) a younger palate (Brit. Mus. M12178), an older palate (Brit. Mus. M12179), and right and left fragments

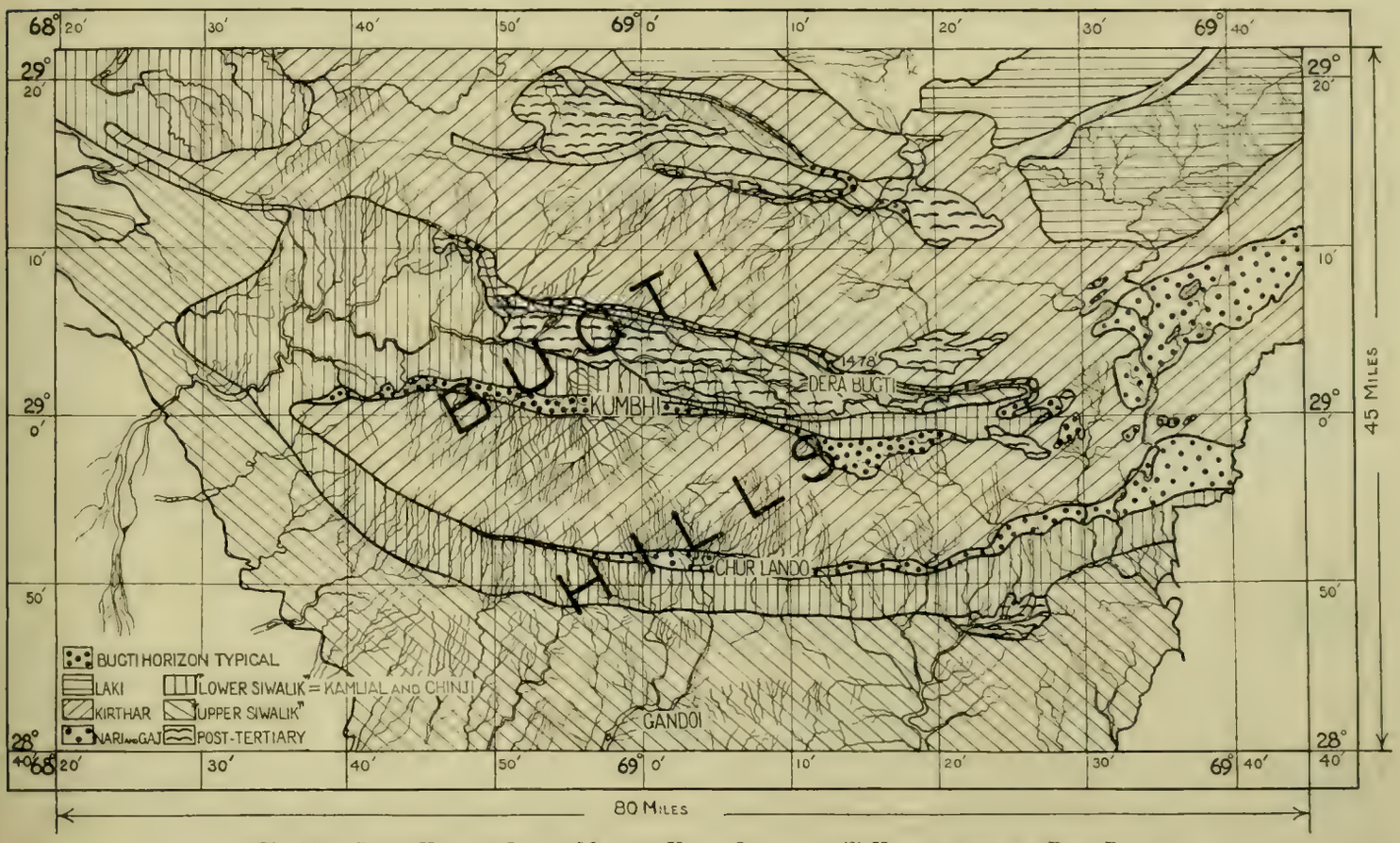


Fig. 221. BUGTI HILLS OF LOWER MIOCENE-UPPER OLIGOCENE (?) HORIZONS WEST OF DERA BUGTI

"Kamlial" (vertical lines) recorded as non-fossiliferous. ='Lower Siwaliks,' base of Manchhar series, Salt Range, northern India. =*Trilophodon palæindicus* life zone.

"Nari" and **"Gaj"** (dotted), of the region of KUMBHI and GANDOI bone bed (yielding cranium *in situ* of *Choeromeryx grandis*), also weathered out specimens or wash-outs in nullahs, as brought in by native collectors. =*Trilophodon cooperi* life zone.

"Chur-Lando," bone bed or quarry, with rich fossil fauna *in situ*, Upper Oligocene. =*Paraceratherium* (*Baluchitherium*) *bugtiense* life zone. No *Trilophodon* or *Deinotherium* remains recorded (see footnote, p. 272, also Fig. 413).

Osborn, 1927: The type mandible of this hyperlongirostrine stage of *Trilophodon* exceeds in measurement the holotype jaw (Amer. Mus. 19421) of *Trilophodon angustidens* var. *chinjiensis* from the Lower Chinji zone. It represents the most progressive *Trilophodon* thus far discovered in India. We cannot agree with Pilgrim, as cited above (*op. cit.*, 1913, p. 309) that the extremely long-jawed *Trilophodon macrognathus* is ancestral to the medilongirostral '*Mastodon*' *punjabiensis* of the Middle Pliocene Dhok Pathan zone, because the latter belongs to the *Tetralophodon* phylum.

of a lower jaw (Brit. Mus. M12181). The latter specimen (Fig. 222) was selected by the present writer (Osborn, 1932.896) as the type of this new primitive species, which he named *Trilophodon cooperi*. As paratypes were selected: (1) The younger palate (Brit. Mus. M12178) "with second molars just erupting" (Cooper, *op. cit.*, fig. 1, p. 611), and (2) the older palate (Brit. Mus. M12179) containing Dp^4–M^2, second molar with two anterior ridge-crests partly worn (Fig. 223).

Registered numbers of the jaw and palates, kindly furnished

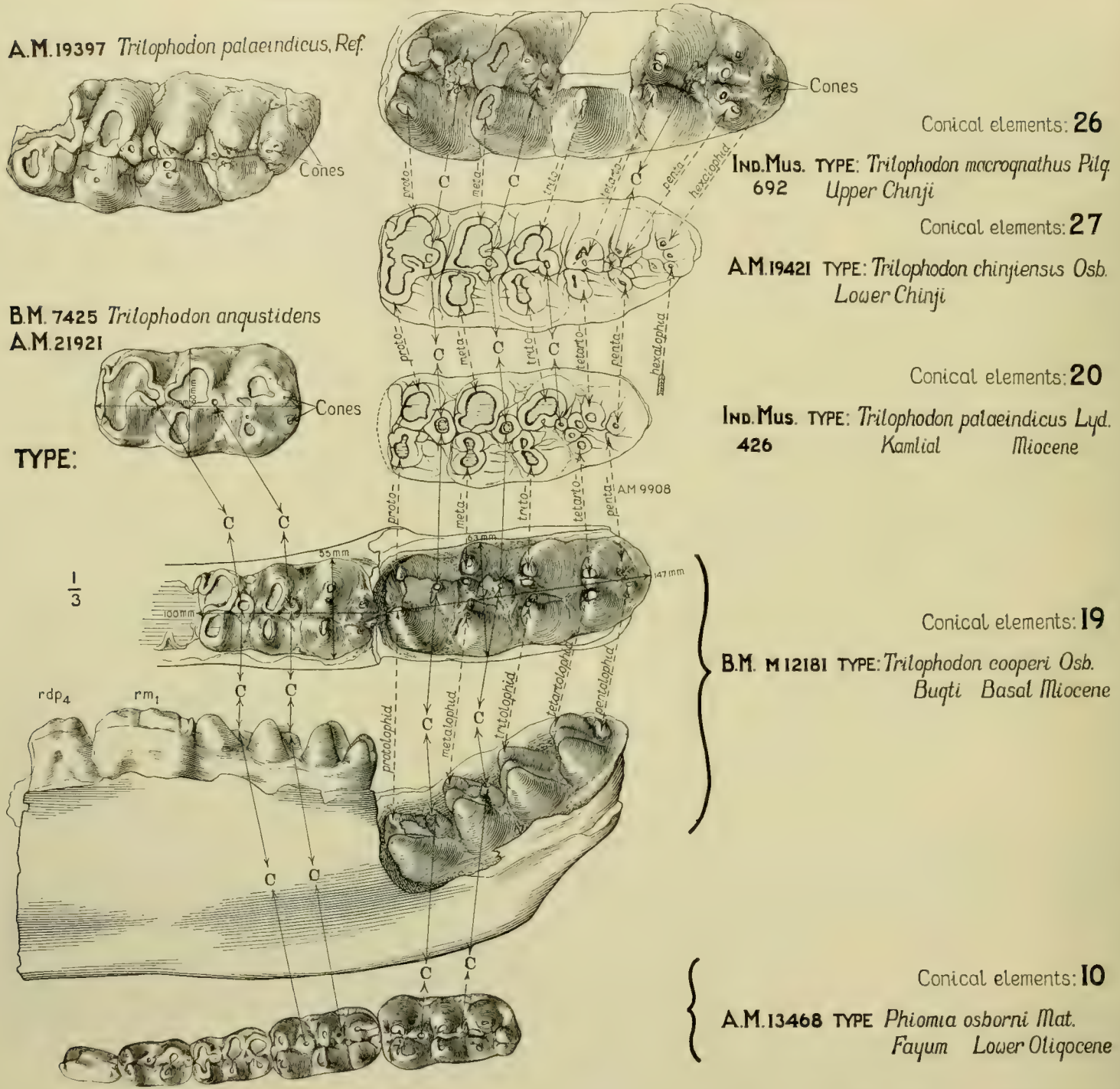


Fig. 222. This evolution comprises: (1) *Central conules* (C C) progressively rising in the median valleys between the -lophids as unique rectigradations in all the Bunomastodontidæ; (2) *duplication* by fission of single cones into conelets; (3) addition of tetarto-, penta-, and hexalophid to the three ridge-crested *Phiomia* stage; (4) ectotrefoils succeeded by entotrefoils. '*Rectigradations*' Osborn (1908) are now termed 'aristogenes' Osborn (1932–1933). Compare Fig. 300, p. 341. For explanation, see "Evolution of 'Central Conules' and 'Aristogenes' in the Trilophodon angustidens Phylum" on page 277 opposite.

		Ridge-crests	Cones	Conelets	Conules	Trefoils	Total conical coronal elements	Total new elements
Mio-Pliocene	*Trilophodon macrognathus*	5½	12	19	4	8	26	34
Mio-Pliocene	*Trilophodon chinjiensis*	5½	12	21	4	14	27	35
Middle Miocene	*Trilophodon palæindicus*	4½	10	17	3	6–7	20	27
Basal Miocene	*Trilophodon cooperi*	4⅕	10	17	2	00	19	19
Lower Oligocene	*Phiomia osborni*[1]	3⅓	8	10	2	00	10	10

[1]*Phiomia osborni* is directly ancestral to the 'shovel-tusker' *Amebelodon fricki* and not to the Longirostrine *Trilophodon* as formerly supposed by Osborn. See footnote on page 277.

by Dr. Arthur T. Hopwood of the British Museum (June 22, 1932) are as follows:

Trilophodon cooperi

Osborn's type: Right ramus, Brit. Mus. M12181 (Cooper, 1922, fig. 2); cast Amer. Mus. 5205. Osborn's paratypes: Older palate, Brit. Mus. M12179, cast Amer. Mus. 5211; younger palate, Brit. Mus. M12178 (Cooper, 1922, fig. 1).

Type and paratype figures of Cooper and Osborn:

Type jaw: Figure 2 of Cooper (1922), figure 222 of present Memoir. Paratype, older palate: Figure 223 of present Memoir. Paratype, younger palate: Figure 1 of Cooper (1922), not figured in present Memoir.

Type Description.—(Osborn, 1932.896, p. 3): "Inferior Molars.—Third inferior molars relatively long and narrow (ap. 147 mm., tr. 63 mm., index 43); with 4½ ridge-crests, relatively obtuse in lateral aspect; internal and external cones subdivided into two conelets; central conules (C C) in first and second valleys only. Second inferior molars relatively long and narrow (ap. 100 mm., tr. 55 mm., index 55), as in *Phiomia osborni;* with 3 obtuse ridge-crests."

"Superior Molars.—Second superior molars relatively broad (ap. 100 mm., tr. 60 mm., index 60); with 3 ridge-crests; no central conules; internal cones subdivided into two conelets; external cones single not subdivided."

It gave the present writer great pleasure to dedicate this very important and geologically ancient new species to his friend C. Forster Cooper, in recognition of his valuable services to mammalian palæontology, especially his two expeditions of the years 1910 (Chur-Lando) and 1911 to the Lower Miocene deposits of Dera Bugti, Baluchistan (Fig. 221).

Cooper in his detailed description and figures (1922) of these Dera Bugti mastodonts, and after comparison with Cuvier's '*Mastodon*' *angustidens* and Schlesinger's '*M.*' *subtapiroidea*, referred the type and paratype specimens to '*Bunolophodon*' *angustidens*. He concluded (*op. cit.*, p. 610), "This is consonant with the view, supported by other reasons, that the stage of *angustidens* represented by these Indian forms is earlier than that of the more typical French forms from Sansan, etc., and is possibly as early as any yet described."

New and very close comparison (Fig. 222) with Cuvier's type of '*Mastodon*' *angustidens*, with Lydekker's type of '*M.*' *angustidens palæindicus*, with Osborn's holotype of *Trilophodon chinjiensis*, and with Pilgrim's type of *Trilophodon macrognathus* confirms Forster Cooper's opinion and demonstrates beyond question that the type of *Trilophodon cooperi* represents an extremely primitive stage in the evolution of the highly characteristic inferior molars of *Trilophodon*. The type and paratype grinding teeth are characterized in the above specific definition.

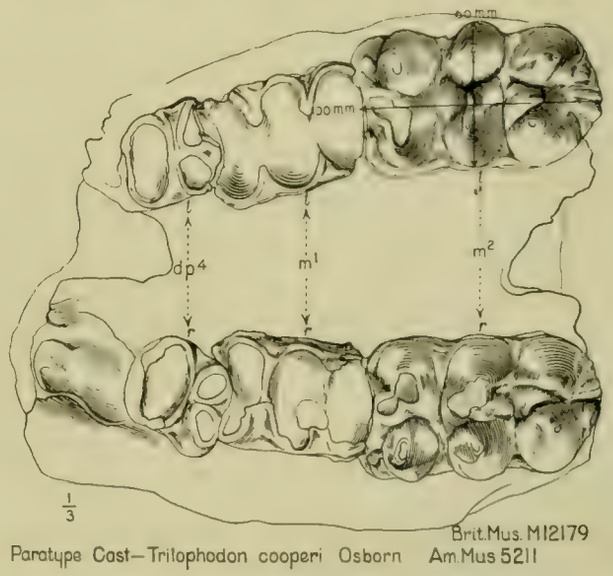


Fig. 223. *Trilophodon cooperi* paratype, 'older palate' (Brit. Mus. M12179) containing Dp^4-M^2; second molar with two anterior ridge-crests partly worn. One-third natural size.

Evolution of 'Central Conules' and 'Aristogenes' in the Trilophodon angustidens Phylum

See Figure 222 opposite[1]

Central conules arise in Phiomia[1] and characterize all specific stages of Trilophodon in Europe, Asia, and North America. First in the inferior, then in the superior molars.

Third Inferior Molars (Fig. 222).—The 'ascending mutations' and species of the *Trilophodon* phylum invariably exhibit the following rectigradations or 'aristogenes' arising orthogenetically:

(1) Central conules (C C) which successively appear between the proto-and metalophid, then between the meta- and tritolophid (*Trilophodon cooperi*), then between the trito- and tetartolophid (*T. palæindicus*), and so on; (2) the paired *cones* each divide into two *conelets*, the fissures becoming deeper progressively from the *Trilophodon cooperi* stage to the *T. chinjiensis* stage; (3) thus the summits of the internal cones wear into a dumb-bell pattern, then into the *trefoil* pattern, by the expansion of the median conules into *trefoils;* (4) each new ridge-crest is heralded by two small cones; as seen also in M_2; (5) the four *ridge-crests*, or proto-, meta-, trito-, and tetartolophids, are followed by the fifth ridge-crest, or pentalophid, which evolves from a rudimentary condition in *Trilophodon cooperi* into the well-developed *T. chinjiensis* stage. Finally the sixth ridge-crest, or hexalophid, is added in *T. chinjiensis* and *T. macrognathus;* (6) the pentalophid progresses through the *Trilophodon cooperi*, *T. palæindicus*, *T. chinjiensis* into the perfected *T. macrognathus* stage, in which finally the hexalophid is heralded as two rounded cones. (7) The conules split into 'conulets' in *T. macrognathus.*

The above four ascending mutations or specific stages compared with the primitive third inferior molar of *Phiomia osborni* enable us to synthesize the progressive evolution of the *Trilophodon* ridge-crests, cones, conelets, conules, and trefoils.

The external elements or ectocones, conelets, conules, and trefoils evolve most rapidly in the *inferior* molars, while the entocones, conelets, and trefoils develop more slowly. In the *superior* molars just the opposite rate is observed, the most rapid evolution is upon the *internal* elements.

Superior Molars (Fig. 223).—The inferior molars are more rapidly progressive than the *superior* molars in which the cones, conelets, and trefoils are greatly retarded; for example, in *Trilophodon cooperi* M^2 exhibits six cones, rudimentary internal trefoils, no conules, whereas the third inferior molar, M_3, exhibits eight cones, two conules, and incipient subdivision of several of the cones and conelets.

[1]The known species of *Phiomia* (Pl. v, pp. 235-236) are directly ancestral to *Amebelodon*, not to *Trilophodon* as formerly supposed.

Geologic Faunal Horizons.—These closely analyzed ascending mutations or stages in the evolution of the third inferior molars afford a new and very valuable time-scale in the ascending geologic horizons of the Upper Siwaliks, as indicated above.

Summary.—(Figs 222, 300) Exclusive of trefoils, *Phiomia osborni* exhibits only 10 conical coronal elements; *Trilophodon cooperi* 19–20 conical coronal elements; *T. palæindicus* 20 conical coronal elements, plus rudiments of trefoils; *T. chinjiensis* 25–27 conical coronal elements, with *prominent* ectotrefoils; *T. macrognathus* 26–37 conical coronal elements, with eight trefoils. A summary of Oligocene-Miocene evolution of M_3 is as follows:

Oligocene: *Phiomia osborni*,[1] length 75 mm., 10 conical coronal elements
Mio-Pliocene: *Trilophodon macrognathus*, length 225 mm., 26–37 conical coronal elements

It follows that this strictly orthogenetic, rectigradational, progressive evolution of the cones, conelets, conules, ridge-crests, and trefoils constitutes not only a sure means of defining generic, mutational, and specific stages, but it may precisely establish the *geologic horizon* on which these definitely ascending evolutionary stages occur. The specific gaps between these readily distinguishable stages in time will be filled in by intermediate ascending mutations.

Trilophodon inopinatus Borissiak and Belĭaeva, 1928

Figure 224

From the Jilančik beds of the Turgai region, Central Asia. Miocene.

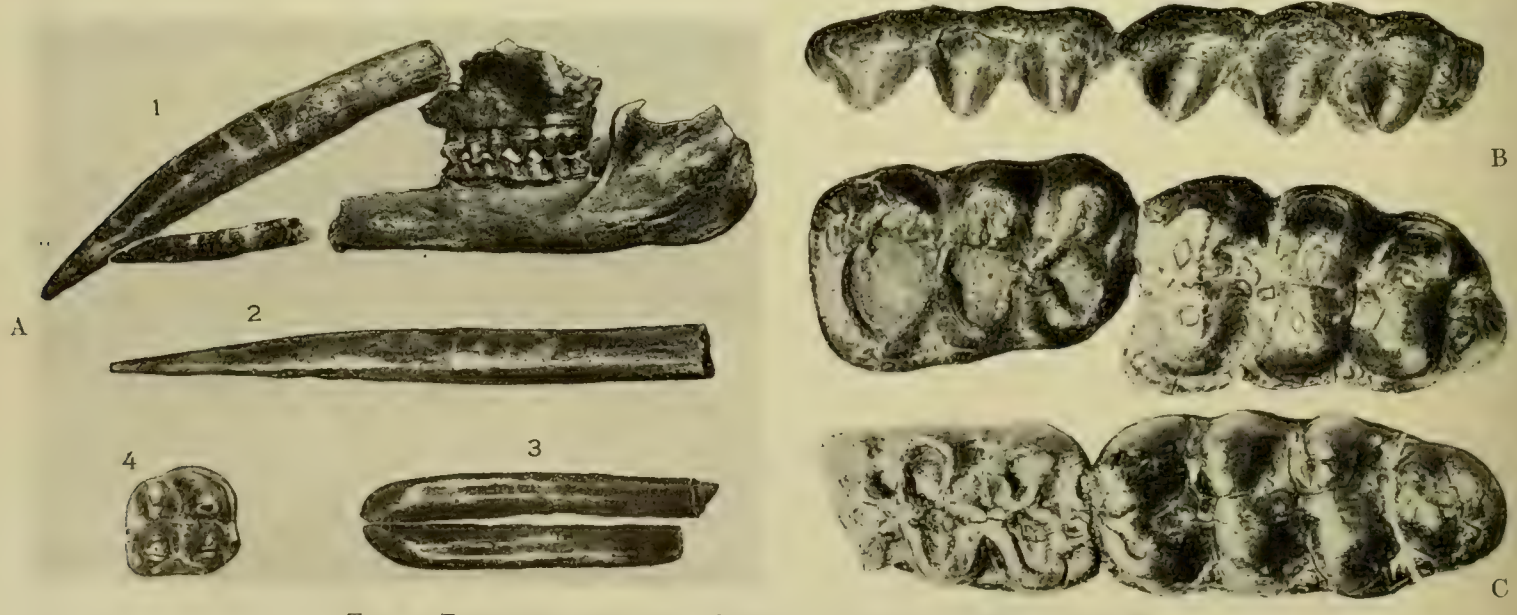
This type was discovered in 1927 (Borissiak, 1927.1, p. 273) in the Miocene Jilančik beds of the Turgai region, beds which also yield *Trilophodon angustidens* ref. and a larger allied form.

Trilophodon (*Serridentinus?*) *inopinatus* Borissiak and Belĭaeva, 1928. "*Trilophodon* (*Serridentinus?*) *inopinatus* N. Sp. from the Jilančik beds of the Turgai Region," Bull. Acad. Sci. l'USSR, 1928, pp. 241–252. Type.—Portions of mandibles, upper jaw, upper and lower molars, and portions of the incisors. Horizon and Locality.—The Miocene Jilančik beds of the Turgai region, Asia. Type Figure.—*Op. cit.*, 1928, Pl. I, figs. 1–6, and Pl. II, figs. 1–7.

Osborn, 1932: This type, fully described and figured by Borissiak and Belĭaeva, 1928, pp. 241–252, Pl. I, figs. 1–6, Pl. II, fig. 4—Fig. 224 of present Memoir) appears to be a *Trilophodon* rather than a *Serridentinus*. The authors consider the *Serridentinus* relationship (pp. 251, 252); this *Serridentinus* affinity is apparently supported by the relatively broad and short (Pl. I, fig. 5) 3½ crested superior molars and the relatively narrow incisive teeth (Pl. I, fig. 3); the type third superior grinders (Pl. I, figs. 5, 6) resemble in proportion *Serridentinus* rather than *Trilophodon*, length 126 mm., maximum width 75 mm., maximum height 46 mm., with a breadth-length index of 60. This index resembles that of *Serridentinus productus* (index 60), rather than that of *Trilophodon angustidens* (index 51). The compressed straight superior tusks, with lateral enamel band, and the inferior uproot tusks resemble those of *S. productus*. The trefoil conules, both upper and lower, appear to be in the center of the crown (Pl. I, figs. 5, 6, Pl. II, figs. 4, 5) rather than along the outer or inner borders of the lophs. While the generic relationship is not positively determinable, we are inclined to agree with the authors that this is a *Trilophodon*.

Measurements

	M^3	M_3
Length	126	139
Breadth	75	62
Height (max.)	46	44
Index	60	45



Type of Trilophodon inopinatus. Compare Ttilophodon cooperi, Figure 222

Fig. 224. Type of *Trilophodon* (*Serridentinus?*) *inopinatus* Borissiak and Belĭaeva, 1928, from the Jilančik beds of Turgai, Asia. Miocene.
A, Anterior portion of cranium, mandible, and grinding teeth. One-tenth natural size. Pl. I, figs. 1–4.
B, Superior grinding teeth of the type. Two-fifths natural size. Pl. I, figs. 5 and 6. Fig. 5, $l.M^2$, $l.M^3$, crown view. Fig. 6, Same, external view (inverted).
C, Inferior grinding teeth of the type. Two-fifths natural size. Pl. II, fig. 4. Fig. 4, $l.M_2$, $l.M_3$.
Observe the absence of the serrate crest characteristic of *Serridentinus*, the presence of central conules characteristic of *Trilophodon*.

[1]See footnote on page 276.

These measurements and the very simple character of the ridge-crests indicate that *Trilophodon inopinatus* is in a very primitive stage of evolution comparable to that of the type (cast Amer. Mus. 5205) of *Trilophodon cooperi* Osb. (Figs. 222, 300) of the Bugti beds of Baluchistan.

	M_3	M^3
Trilophodon cooperi type and ref.		
Length	147	128
Breadth	63	72
Index	43	56
Trilophodon inopinatus type		
Length	139	126
Breadth	62	75
Index	45	60

Both in the number and height of the ridge-crests and in the measurements and indices, as well as in the feeble development of the intermediate conules, the type of *Trilophodon inopinatus* from Turgai agrees quite closely with the type of *T. cooperi* from the Bugti beds of Baluchistan (cf. Forster Cooper, 1922, fig. 1, p. 611, fig. 2, p. 614, and measurements, p. 625, of *Bunolophodon angustidens*, upper and lower jaws, Brit. Mus. M12179 and M12181, casts Amer. Mus. 5211 and 5205).

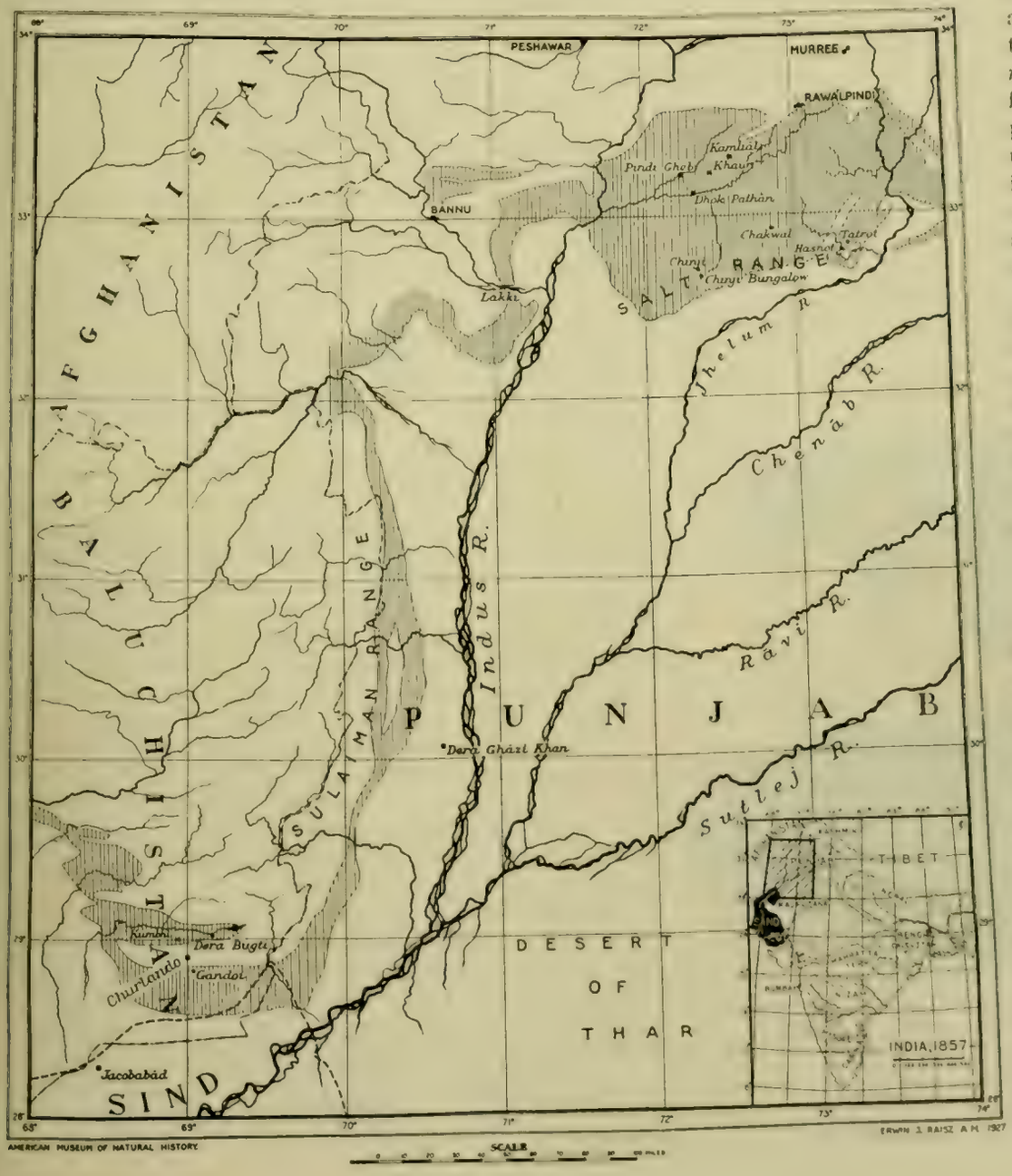
Trilophodon hasnotensis sp. nov.

Figure 417

From 4½ miles northwest of Hasnot, India, 1000 feet below Bhandar bone bed, lower Middle Siwaliks. Middle Pliocene. See type figure 417 in Chap. X, p. 454.

The median conules displayed in figure 417 (Amer. Mus. 19399) prove that this specimen belongs to the genus *Trilophodon* rather than to the genus *Serridentinus* in which the median conules are invariably absent; also this specimen lacks the ectotrefoil spurs characteristic of *Serridentinus*. Although an imperfect fragment, it is interesting and important as representing a hitherto unknown Middle Pliocene stage in the ascending series of *Trilophodon*. Accordingly the new specific name *Trilophodon hasnotensis* is hereby assigned to it.

Geology.—Hasnot, equivalent in age to the Dhok Pathan, was the base of Barnum Brown's measurements (1922, 1923) of the Middle Pliocene levels of the fossils collected in the Bhandar bone bed.



Classic Fossil Mammalian Exposures of Northwestern India
After map by Erwin J. Raisz, A.M., 1927

Fig. 225. The great Tertiary piedmont, fluviatile, and flood-plain horizons dissected by the western and northern tributaries of the river Indus, from Upper Oligocene (Chur-Lando) to Middle Pliocene (Dhok Pathan) time. Bordering the mountain ranges of Baluchistan, Afghanistan, and the northern Punjab (Salt Range) is a northern to southern area of Tertiary sediment of 400 miles, with a collective thickness of 25100 ft. (see Fig. 413). Compare also figure 221, page 275.

Middle Pliocene: Dhok Pathan, in the Salt Range.

Middle Miocene and Mio-Pliocene: Chinji Bungalow, Hasnot, Tatrot, Chakwāl, and Kamliāl in the Salt Range.

Lower Miocene: Gandoi and Kumbhi in the Bugti Hills.

Upper Oligocene (?): Chur-Lando in the Bugti Hills.

10. TRILOPHODONTS OR SERRIDENTINES OF JAPAN

The type of the species *Trilophodon sendaicus* Mats. is described and figured under *Trilophodon*, although like *Hemimastodon annectens*[1] Mats. it might for some reasons be placed under the Serridentinæ; this type exhibits the central conules in the center of the valleys which characterize *Trilophodon* and which are not present in *Serridentinus*. The phyletic relationship of *H. annectens* and of *T. sendaicus* will only be settled by the discovery of a jaw of each of these species, the characters of which have not hitherto been described. For the present, therefore, *H. annectens* is provisionally placed in the Serridentinæ, namely, *Serridentinus annectens* (Chap. X below).

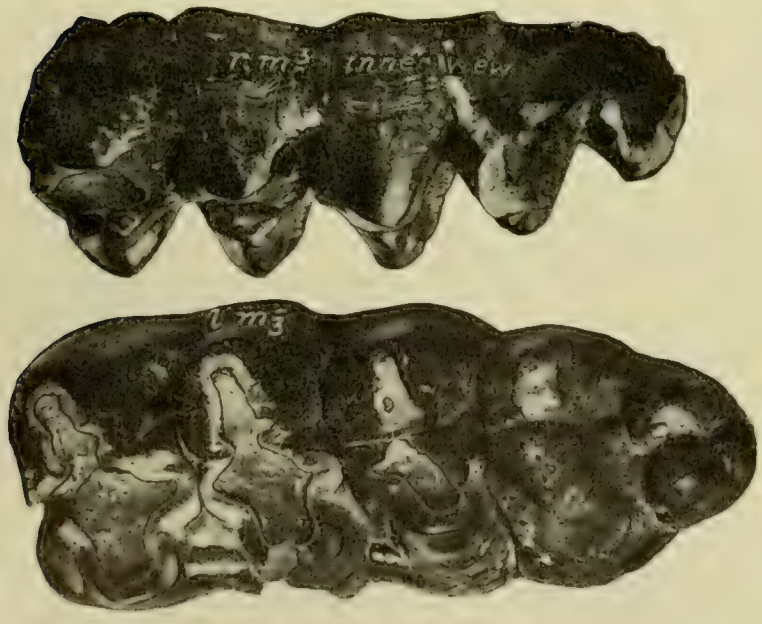
Trilophodon sendaicus Matsumoto, 1924

Figure 226

From Kitayama, near Sendai, Province of Rikuzen, Japan. Tatsunokuchi formation, Lower Pliocene.

Trilophodon sendaicus Matsumoto. "Preliminary Notes on Two New Species of Fossil Mastodon from Japan," Journ. Geol. Soc. Tôkyô, Vol. XXXI, 1924, pp. 402, 408. TYPE.—Upper right M^3, lower left M_3, and two fragments of a lower right M_3, besides left astragalus, probably belonging to one and the same individual. HORIZON AND LOCALITY.—(Compare Matsumoto, 1926.1, pp. 6, 9) Kitayama, near Sendai, Province of Rikuzen, Japan. From soft, sandy tuff probably referred to the Tatsunokuchi formation. The Tatsunokuchi formation is probably to be referred to upper Pontian or Pliocene-Pontian, while the Sawoyama formation proper, which corresponds to the horizon of *Prostegodon* [=*Stegolophodon*] *latidens*, probably should be referred to typical Pontian, as judged from both the fossils and the stratigraphical position of the beds. TYPE FIGURE.—Matsumoto, 1926.1, Pls. III and IV.

Matsumoto makes a comparison of this species with the following forms: *Mastodon pyrenaicus* Lartet (pars), *M. pyrenaicus* Lartet (pars) larger type, *M. falconeri* Lydekker, of India, and *M. lydekkeri* Schlosser, of China.



TYPE OF TRILOPHODON SENDAICUS

Fig. 226. Type teeth, r.M^3, l.M_3, of *Trilophodon sendaicus*. After Matsumoto, 1926.1, Pl. III, figs. 2 and 3, one-half natural size.
(Upper) r.M^3, internal aspect.
(Lower) l.M_3, crown aspect.

SPECIFIC CHARACTERS.—(Compare Matsumoto, 1926.1, pp. 7 and 8) Length of M^3 along median line $186+a$ ($188\pm$) mm. Mesial longitudinal cleft evident throughout, so that each ridge is divided into inner and outer cusps. Tips of little worn or unworn cusps rather acute, being less blunt or rounded than in *Hemimastodon annectens* and *Trilophodon angustidens typicus*. Median accessory cusps rather feebly developed, so that the trefoil pattern of the inner cusps is not very complete and the valleys are widely open. Outer cusps consist each of two secondary cusps arranged transversely, the outer one of which is much more prominent than the inner. Outer secondary cusp provided with two spurs—one each on the anterior and the posterior side, as a characteristic of the tapiroid and subtapiroid mastodonts. Posterior talon very strong; its inner cusp very large and stout, outer one very small and low, having the appearance of an outer accessory cusp. Anterior talon well developed. Internal basal cingulum very feeble; external basal cingulum represented by a very low tubercle at outer entrance only of first valley, being entirely absent at second ridge and backward.

Length of M_3 along median line, right 203 mm., left 206 mm. Characteristics of mesial longitudinal cleft, tips of cusps, median accessory cusps and valleys exactly like those observed in the upper tooth. Spurs of inner cusps less prominent than those of outer cusps of upper tooth. Tooth concavo-convex in general outline seen from above, its outer side from first to third ridge being slightly concave and its inner side considerably convex throughout. Anterior talon well developed. No internal basal cingulum; external basal cingulum present but feeble, being represented by very low tubercles. Enamel layer of both upper and lower teeth very thick.

Osborn, 1927: The length of the inferior molars (203–206 mm.) agrees closely with that of the American Pliocene species shown in the comparative table of measurements below, e.g., *Trilophodon osborni* (196 mm.), *Amebelodon* (*Trilophodon*) *hicksi* (199 mm.), *T.* (*Megabelodon*) *lulli* (222 mm.), and *T. pojoaquensis* (220 mm.).

Osborn, 1932: The presence of *central conules*, now recognized as the highly distinctive character of the third inferior grinding teeth of members of the *Trilophodon* phylum (Fig. 222), renders it certain that this Japanese species belongs in the genus *Trilophodon* rather than in *Serridentinus*. The presence of the *Serridentinus* phylum in Japan appears to be rendered certain by the species *Serridentinus annectens* Mats., which has the bluntly rounded ridge-crests, also characteristic of *S. browni* of the Siwaliks of India.

[1]Matsumoto erroneously referred this species to Pilgrim's genus *Hemimastodon* which proves to belong to the SUINA.

11. MIOCENE AND PLIOCENE MASTODONTS OF BADEN AND RHEINHESSEN, KLÄHN, 1922

In the year 1922 Dr. Hans Klähn of Freiburg i. B. reviewed the Middle Miocene mastodonts of Baden in his paper "Die badischen Mastodonten und ihre süddeutschen Verwandten," including the bunolophodont and zygolophodont phyla, and added valuable descriptions and measurements of collections from Mösskirch, Steinheim, Eppelsheim, Esselborn, Bermersheim, Wiesberg, Kettenheim, Westhofen, Wolfsheim, Dintesheim, Wahlheim, Herbolzheim, and Krottling, all of which are carefully plotted (Tab. 1) as to their localities in southern Germany.

Within the single generic term *Mastodon*, Klähn included *fourteen* species which in the present Memoir are redefined by Osborn within the following five genera:

Trilophodon (*Mastodon*) *angustidens* Cuvier
Trilophodon (*Mastodon*) *engelswiesensis* n. sp.
Turicius (*Mastodon*) *turicensis* Schinz
Serridentinus (*Mastodon*) *subtapiroideus* Schles.
Trilophodon (*Mastodon*) *steinheimensis* n. sp. (Fig. 228)
Tetralophodon (*Mastodon*) *longirostris* Kaup
Trilophodon (*Mastodon*) *austro-germanicus* Weg.
Trilophodon (*Mastodon*) *esselbornensis* n. sp. (Fig. 227)
Turicius (*Mastodon*) *wahlheimensis* n. sp. (Fig. 229)
Tetralophodon (*Mastodon*) *longirostris* (*dubius*) Kaup
Tetralophodon (*Mastodon*) *longirostris* (*grandis*) Kaup
Tetralophodon (*Mastodon*) *gigantorostris* n. sp.
Anancus (*Mastodon*) *minutoarvernensis* n. sp.
Anancus (*Mastodon*) *gigantarvernensis* n. sp.

Of the *six new species* enumerated above the following brief descriptions may be given. We are indebted to Doctor Klähn for clichés of his type of *Trilophodon esselbornensis* and of his two cotypes of *Turicius wahlheimensis*.

Trilophodon engelswiesensis Klähn, 1922

Engelswies, Baden, Germany. Miocene.

Klähn, *op. cit.*, 1922, p. 30, fig. 10.

Type.—Posterior half of a right third superior molar, r.M^3, from Engelswies, with single internal median trefoils, length of fragment 99 mm., breadth 74 mm., breadth of talon 46 mm., resembling *Trilophodon angustidens*.

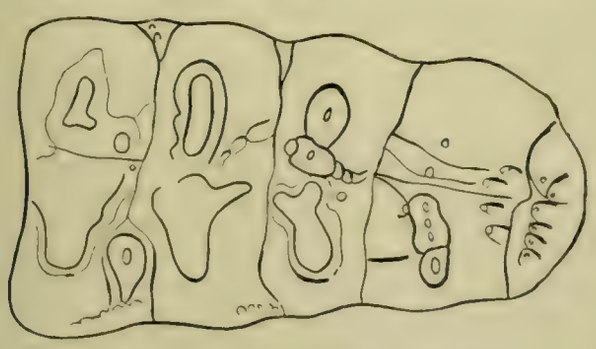
Trilophodon esselbornensis Klähn, 1922

Figure 227

Esselborn and Westhofen, Rheinhessen, Germany. Pliocene.

Klähn, *op. cit.*, 1922, p. 73, and p. 92, fig. 24, reproduced herein as figure 227. Generic reference doubtful.

Type.—A left third superior molar, l.M^3, from Westhofen, in the Darmstadt Museum, length 158 mm., breadth 82–83 mm., five ridge-crests, of which the three anterior exhibit prominent double trefoils, crown narrowing posteriorly.



Type of Trilophodon esselbornensis

Fig. 227. Type left third superior molar, l.M^3, of *Mastodon esselbornensis* Klähn, 1922, p. 92, fig. 24, from Westhofen, Rheinhessen, Germany. Darmstadt Museum. Length 158 mm., breadth 82 mm. Observe entotrefoils on three anterior crests. One-half natural size.

Trilophodon steinheimensis Klähn, 1922

Figure 228

Steinheim, Baden, Germany. Middle to Upper Miocene.

This type appears to be related to '*Mastodon*' *angustidens* and therefore referable to *Trilophodon*. Oscar Fraas (1870, pp. 184, 185) described from Steinheim and figured (*op. cit.*, Taf. v, fig. 1) a third right inferior molar, r.M_3, as *Mastodon arvernensis:* "Fig. 1 ist der letzte untere Backenzahn der rechten Kieferhälfte in nat. Grösse abgebildet. Seine grösste Länge ist 0^m 214, seine grösste Breite über der mittlern Querreihe gemessen 0^m 09. Er theilt sich in seiner Längenaxe in 2 Hälften, eine innere und äussere, die innere Hälfte ist bei der Krümmung, welche der Zahn macht, um 2 CM. kürzer als die äussere, indem der Raum zwischen dem 1ten und 5ten Hügel der Innenseite 0^m 16, derselbe aber aussen 0^m 18 misst."

In 1922 Klähn made the same tooth the type of *Mastodon steinheimensis*, agreeing with Vacek as to its relationship to *M. angustidens* rather than to *M. arvernensis;* with the type molar (Fig. 228) were associated portions of superior and inferior incisors, the superior incisors having the characteristic enamel band. The molar is characterized by Klähn (1922, pp. 35, 76) as follows: [p. 35] "Der tadellos erhaltene, Fraas als Original einst dienende $_3$M (Keim) besitzt 4 H.R.+ einem zweihöckrigen selbständigen Talon. Am Vorderende befindet sich ein kräftiges Bourrelet. Das Auffallendste an dem Zahn ist die starke, fast knickartige Umbiegung zwischen I und II. Vordere Sp.H. befinden sich an I, II, III prätrit. . . . Die Täler sind schmal, nur dasjenige zwischen III und IV posttrit ist etwas weiter. Zu betonen ist, dass auch bei den folgenden Unterkieferzähnen die genannten Merkmale wiederkehren, besonders der auffallende Knick am Vorderende des Zahnes, so dass schon dieses Merkmal etwas für *M. steinheimensis* Charakteristisches ist. [p. 76] Die Knickung dürfte wohl auf eine Überentwicklung des Zahnes

hindeuten. Dieser gehört auf jeden Fall zu einem jener hochentwickelten *angustidens*-Formen, die wie *steinheimensis* oder *austrogermanicus* für das Obermiozän typisch sind.

steinheimensis sp. (39) Br I oder II: ca. 85,0 Br II oder III: 90,5 Br III oder IV: 92,0 Br. IV oder V: 69,0

Klähn (1931, p. 5) observes: "Vacek [Footnote: 'Über österr. Mastodonten u.s.w. Abh. d. K. K. geol. Reichsanst. Bd. VII, Wien 1877.'] rechnet den Steinheimer, von Fraas beschrieben, $_3$M zu einer 'Übergangsform' von *angustidens* zu *longirostris*, worin ihm

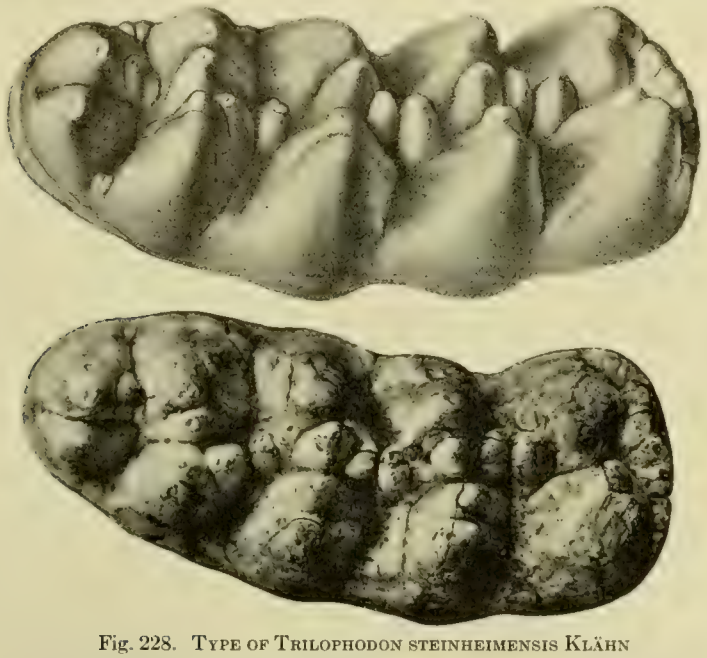


Fig. 228. Type of Trilophodon steinheimensis Klähn

Both figures about two-fifths natural size. Observe large central conules.

(Upper) Type third left inferior molar, l.M_3, of *Mastodon steinheimensis* Klähn, 1922, pp. 35, 76. From Steinheim, Germany. After Fraas, 1870, Taf. v, fig. 1, who referred it to *Mastodon arvernensis*. Length 214 mm., breadth 90 mm.

(Lower) Same molar, but referred by Klähn, 1931, Taf. III, fig. 2, to *Mastodon angustidens steinheimensis*. Stuttgart, J. N. 4767.

Schlesinger [Footnote: 'Die Mastodonten des naturhist. Hofmus. Denkschr. d. K. K. nat. Hofmus. I, Wien, 1917.'] folgt. . . . Der Steinheimer Zahn erinnere aber doch schon insofern stark an *longirostris*, als die Sekundarhöcker mächtiger als bei *angustidens* von Eibiswald (=f. *subtapiroidea* Schl.) seien, wodurch die Haupthöcker mehr als bei dieser Form auseinanderrücken. . . . Es handelt sich, wie wir sehen werden, um eine Form mit subtapiroider Basis; sie ist wohl gegenüber f. *subtapiroidea* fortgeschritten, aber nicht in Richtung *longirostris*."

Osborn, 1931: Thus Vacek and Klähn rightly claim that this type molar (Fraas, 1870, Taf. v, fig. 1, Klähn, 1931, Taf. III, fig. 2) is related to '*Mastodon*' *angustidens* rather than to '*M.*' *longirostris*.

Turicius wahlheimensis Klähn, 1922

Figure 229, also Pl. III J

From Wahlheim and Esselborn, Rheinhessen, Germany. Pliocene.

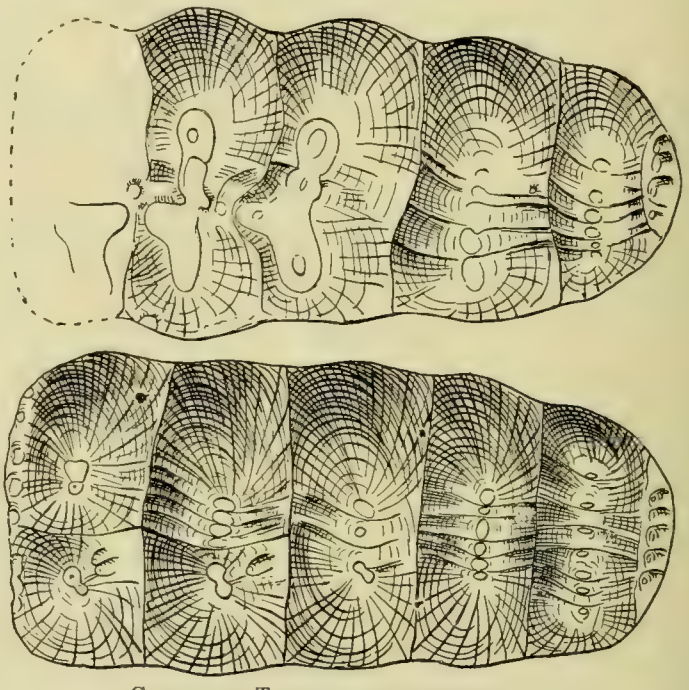
Klähn, *op. cit.*, 1922, pp. 76, 77, fig. 17, and p. 94, fig. 25; reproduced herewith as figure 229.

Cotypes.—Third left superior molars, l.M^3, from Wahlheim and from Esselborn, in the Darmstadt Museum (Nos. 188 and 189 respectively). Comparative measurements of these third superior cotype molars are as follows:

Wahlheim: l.M^3, length 190 mm., maximum breadth 93.5 mm.

Esselborn: l.M^3, length 186 mm., maximum breadth 88 mm.

There are five ridge-crests with conelets closely compressed at the summits in the metaloph, tritoloph, tetartoloph, and pentaloph; there is a vestige of a hexaloph.



Cotypes of Turicius wahlheimensis

Fig. 229. Cotypes of *Mastodon wahlheimensis* Klähn, 1922. One-half natural size.

(Lower) Third left superior molar, l.M^3, from Esselborn, Rheinhessen, Germany. Five ridge-crests. Length 186 mm., breadth 88 mm. Darmstadt Mus. 189. After Klähn, 1922, p. 77, fig. 17.

(Upper) Third left superior molar, l.M^3, from Wahlheim, Rheinhessen, Germany. Length, 190 mm., breadth 93.5 mm. Darmstadt Mus. 188. After Klähn, 1922, p. 94, fig. 25.

Tetralophodon gigantorostris Klähn, 1922

Bermersheim, Rheinhessen, Germany. Pliocene.

This type appears to be related to '*Mastodon*' *longirostris* and therefore referable to *Tetralophodon*.

Klähn (1922, p. 87) described as *Mastodon gigantorostris* n. sp. a lower jaw in the Mainz Museum, distinguished from the mandibles of other mastodonts, especially from *longirostris*, as follows: "1. Die Anwesenheit eines deutlich hervortretenden Angulare. Während bei den Mandibeln des *longirostris* der Ramus horic. in steiler Kurve in den Ram. asc. übergeht, ist dieselbe bei *gigantorostris* flacher und springt unterhalb der Condylen zum Angulare zurück. 2. Der Proc. coron. und der Condylus steigen nicht so hoch wie bei *longirostris* auf. 3. Während beim ausgewachsenen *longirostris* Proc. coron. und Condylus etwa in gleicher Höhe und verhältnismässig nahe beieinander liegen, ist bei *gigantorostris* der Proc. coron. viel tiefer als der Condylus gelegen und entfernt sich ziemlich weit von diesem. Deshalb steigt der erstere direkt am hinteren Teil des $_3M_3$ bei *gigantorostris* in die Höhe,

während er bei *longirostris* etwas weiter zurückliegt. 4. Die Symphyse ist vollkommen gerade, während sie bei *longirostris*± nach unten gesenkt ist. Die Symphysenregion reicht sehr weit zurück—bis zu $_2M_2$—, ein Merkmal, durch das sich *gigantorostris* dem *M. grandis* nähert. 5. Die $_2J_2$ treten ohne jede Krümmung aus den Kiefern hervor, zeigen auch keine Divergenz. Die genannten Unterschiede sind so wesentlicher Natur, dass ich mich berechtigt fühle, *gigantorostris* von *longirostris* abzutrennen."

Measurements

Length of mandible (*gigantorostris*) from angle to alveolus	770 mm.
Height of same	288
Height of mandible (*grandis*) from Esselborn	163
Length of M_3 (Cat. No. 389)	220
Breadth of same	86

"In der Korrelation L: mittl. Br. besteht scheinbar kein Unterschied gegenüber *grandis* (Tab. III), so dass wir bei losen Zähnen nicht entscheiden können, ob *gigantorostris* oder *grandis* vorliegt. Es muss noch mehr einwandfreies Material gefunden werden, um die Stellung der *gigantorostris*-Zähne genau angeben zu können."

Anancus minutoarvernensis and **A. gigantarvernensis** Klähn, 1922

Herbolzheim, Baden, Germany. Pliocene.

These imperfectly defined subspecies appear to be related to '*Mastodon*' *arvernensis* or *Anancus* of the present Memoir. They may be larger and smaller races of *arvernensis*, or male and female variations of the same species.

Klähn (1922, p. 102) distinguishes between the larger and the smaller race of brevirostrine mastodonts from the Val d'Arno, without a figure or a clear designation of either type; he refers to the descriptions and measurements of Schlesinger, based on lower jaw fragments in the Berlin Museum, also from the Val d'Arno. According to his own correlation table, Klähn (*op. cit.*, p. 134) places these subspecies as follows:

Bunolophodonte Reihe		Zygodonte Reihe	
M. arvernensis		*M. borsoni*	Middle and Upper Pliocene
minutoarvernensis	*gigantarvernensis*		
M. longirostris			Lower Pliocene
dubius	*grandis*		
		M. turicensis sp.?	

12. THE LOWER MIOCENE TRILOPHODONT OF FRANCE (TRILOPHODON PONTILEVIENSIS) COMPARED WITH THE PRIMITIVE TRILOPHODON COOPERI OF BALUCHISTAN

The *Trilophodon pontileviensis* cotype (Fig. 230, left) of the Lower Miocene of France, exhibiting 23 to 26 conical elements or *aristogenes*, is somewhat more progressive than the *T. cooperi* of the Bugti Hills, Lower Miocene of Baluchistan (Figs. 222, 300), with 19–20 aristogenes; it is more closely similar to *T. palæindicus* of the Middle Miocene of India with 20 aristogenes; it is much more primitive than the *T. chinjiensis* of the Mio-Pliocene of India (25–27 aristogenes), also than the *T. macrognathus* of the Mio-Pliocene (26–37 aristogenes). *T. pontileviensis* demonstrates the very early migration of these primitive Trilophodonts from southern Europe to southern Eurasia.

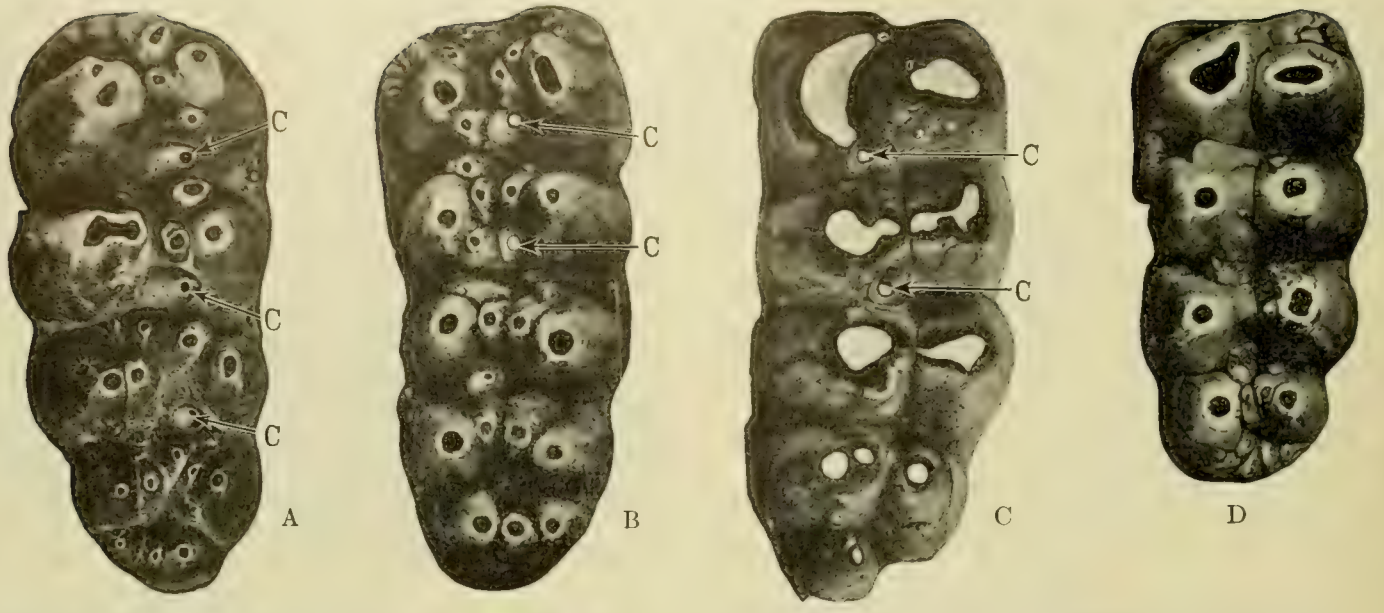
Trilophodon pontileviensis Mayet-Fourtau, 1918

Figures 138 A, B, 139, 2, and 230

From Chevilly, Pontlevoy, Sables de l'Orléanais du Blésois, France. Lower Miocene.

The Lower Miocene *Trilophodon pontileviensis* (Figs. 138 A, B, 139, 2) exhibits two or three central conules (C, C) in the valleys, and are now known to be paralleled by the types of *Trilophodon cooperi* from the Bugti horizon, Lower Miocene, Baluchistan (cf. Fig. 222 with Fig. 230, this chapter). Mayet (1908, pp. 190–198, Pls. VII, XI) simply referred these teeth to '*Mast. angustidens*'; they may now be given provisionally the specific name *Trilophodon pontileviensis*. Certain specimens, e.g., Pl. VII, figs. 5 and 6, differ from the types of *T. cooperi* in having stronger trefoils, while others (Pl. XI, fig. 2) do not exhibit trefoils and are thus closer to *T. cooperi*. The *central conules* shown in Mayet's figures and retouched in our figure 230 A-C are similar to those in the type mandible of *T. cooperi* (Brit. Mus. M. 12181); the measurements of M^3 are:

Fig. 230	ap.	tr.	I.
C,	163	72	44
A,	162	72	44
B,	158	72	46



THIRD INFERIOR[1] MOLARS: (A-C) COTYPES OF TRILOPHODON PONTILEVIENSIS MAYET-FOURTAU, 1918; (D) TYPE OF MIOMASTODON DEPERETI SP. NOV., AFTER MAYET, 1908, PL. VII, FIG. 3 (CF. FIGS. 138 A, B, AND 139, 2 OF PRESENT MEMOIR). ALL FIGURES ONE-HALF NATURAL SIZE

Fig. 230. Mayet (1908, pp. 190-194) distinguishes and figures (Pl. VII, figs. 6 [C], 5 [B], and Pl. XI, fig. 2 [A]) the '*Mast.*' *angustidens* as follows:

(1) Symphysis greatly elongated in front of the molars. (2) Molars narrow and of relatively small size. (3) Premolars trilophodont. (4) Molars with obtuse cones and crests, alternating conelets, valleys interrupted by secondary conelets (central conules). (5) Superior tusks cylindrical at the base, compressed and prismatic at the extremity, lightly spiraled with external band of enamel. (6) Inferior incisors deeply implanted, flattened, without enamel band. (7) Third inferior molar with four complete crests, the fifth crest variable. (8) *Mast. angustidens* of Pontlevoy smaller than that of Orléanais and apparently more complex. An *M. angustidens* of larger size and much more complicated is from Steinheim (cf. *Trilophodon steinheimensis* Klähn, Fig. 228 of the present Memoir). (9) Osborn, 1934: (A) Aristogenes = 24–26; (B) aristogenes = 23–24. Compare *Trilophodon cooperi* (Fig. 300, p. 341), aristogenes 19–20.

(D) Mayet, 1908, Pl. VII, fig. 3: Type of *Miomastodon depereti* sp. nov. (described in the Appendix at the close of the present Vol. I), the Lower Miocene stage of the true Mastodon. The measurements of this type molar are: l.M_3, ap. 129 mm., tr. 65 mm., index 50.

13. MIGRATION OF EURASIATIC TRILOPHODON AT THE CLOSE OF THE MIOCENE

So far as now known, *Trilophodon* became rare, or migrated from Eurasia to America, at the close of Miocene or beginning of Pliocene time both in Europe and Asia, to be replaced in Eurasia by *Tetralophodon* beginning with the *Tetralophodon longirostris* of Eppelsheim. Pliocene Trilophodonts are *Trilophodon* (*Choer.*) *pentelicus* (Figs. 205, 206) of Pikermi, and *T. hasnotensis* (Fig. 417) of Hasnot, India.

It should be clearly understood that the above synopsis of the types and type descriptions of the twelve European, Asiatic, and North African stages of *Trilophodon* is preliminary to full monographic research, which can only be made by comparison and measurement of the original type and referred specimens not available to the present author. Doubtless the evolution phases in the successive mutations and species in the Miocene and Lower Pliocene of Europe, including Greece, will become as clearly definable as those of southern Asia represented in the synthetic figure (Fig. 222).

As we have observed, the prominent *central conules* in the inferior valleys distinguish all the truly referred species of *Trilophodon* in the present chapter, as clearly seen in the third inferior molars of *Trilophodon cooperi* (Fig. 222), of *T. palæindicus* (Fig. 222), of *T. chinjiensis* (Fig. 222), of *T. macrognathus* (Figs. 219, 222), of *T. angustidens* (Fig. 222), of *T. steinheimensis* (Fig. 228). They reappear in America in *T. willistoni* (Figs. 239, 240), in *T. osborni* (Figs. 251, 252), in *T. giganteus* (Fig. 259), and in *T. pojoaquensis* (Fig. 276). *T. hasnotensis* (Fig. 417) appears to be the final stage in India.

[1]Identified by Mayet, 1908, caption to Plate VII, as third superior molars.

14. BRACHYODONT, FOREST-LOVING SPECIES OF THE EAST COAST OF NORTH AMERICA

(December, 1932) On very close reëxamination of the cast (Amer. Mus. 1909) of Leidy's classic type (Figs. 232, 233) of 'Mastodon' obscurus, also of the original type molar fragments of 'Serridentinus' simplicidens Osborn, these two species prove to belong in the genus Trilophodon because of the presence of 'central conules' uniting as central trefoils with the median conules.

Trilophodon simplicidens Osborn, 1923

Figures 231, 350B1, B2

From the Bone Valley formation, Lower Pliocene, near Pierce, Polk County, Florida.

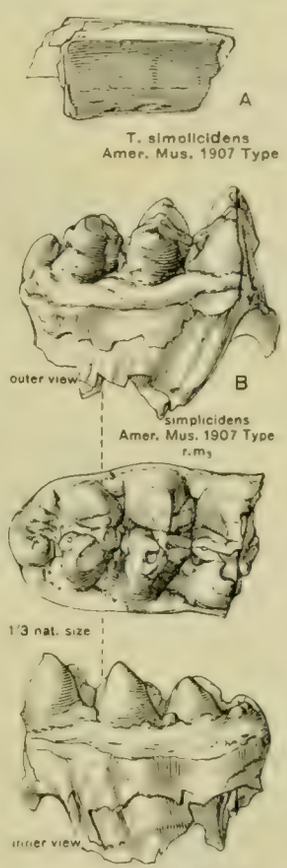
This very primitive species occurs in the Bone Valley formation of Florida, regarded as of Lower Pliocene age; it is, however, much more primitive than species usually found in the Pliocene and may be intrusive from older Miocene beds. The ridge-crests (height 35 mm.) are much lower than in *Trilophodon obscurus* (52 mm.), as shown in comparative figure 350, B1, C1.

The original description by Osborn[1] is as follows:

Serridentinus simplicidens Osborn, 1923. "New Subfamily, Generic, and Specific Stages in the Evolution of the Proboscidea." Amer. Mus. Novitates, No. 99, December 27, 1923, p. 2. TYPE.—A third inferior molar of the right side, r.M_3 (Amer. Mus. 1907). HORIZON AND LOCALITY. Lower Pliocene or Miocene (?), near Pierce, Florida. TYPE FIGURE.—Figure 231 of the present Memoir.

TYPE DESCRIPTION. — (*Op. cit.*, Osborn, 1923.601, p. 2): "This is the smallest and simplest member of the *Serridentinus* phylum thus far found on the southeast coast of the United States. The type of the species is a molar tooth, Amer. Mus. 1907 (and associated fragments), from Lakeland [near Pierce], Florida, presented by Mr. C. R. Halter in 1922, and originally identified by Osborn (in 1922) as '*Mastodon*' *obscurus* Leidy. A comparison with the type of '*Mastodon*' *obscurus* (Philadelphia Acad. 13278) shows that the specific stage of *Serridentinus simplicidens* is more bunodont, the cones and crests being lower and much simpler, and the lateral crests of the outer cones less fully developed."

In a simpler stage of evolution than the type of *M.* [*Trilophodon*] *obscurus* is the type molar, r.M_3, of *T. simplicidens* (Fig. 231), together with fragments of tusks, of pelvis, of femur, and of ribs, also head of humerus, of somewhat doubtful association (Amer. Mus. 1907) from near Pierce, Florida, kindly presented to the American Museum in 1922 by Mr. C. R. Halter, in charge of the Biology Department of Southern College, Lakeland. The molar fragment of M_3 consists of the posterior half of the metalophid, the tritolophid, the tetartolophid, and the talonid; as in *T. obscurus*, the trefoil is conspicuous on the outside of the crown, a rudimentary trefoil appears on the anterior face of the tritolophid. Other type fragments are the superior tusks (Fig. 231A—vertical diameter 43 mm., transverse diameter 40 mm.). Mingled with the above fragments were bones belonging to other unassociated animals.



TYPE OF TRILOPHODON SIMPLICIDENS

Fig. 231. Type of *Serridentinus simplicidens* Osborn, 1923 (Amer. Mus. 1907). A specimen, r.M_3, from near Pierce, Florida, presented to the American Museum by Mr. C. R. Halter in 1922; from the Bone Valley formation, probably of Lower Pliocene age. One-third natural size.

The association of the tusk (A) with the grinding tooth (B) is doubtful; A and B may belong to different individuals.

COMPARISON WITH T. OBSCURUS.—Consequently the *T. simplicidens* type molar belongs to (1) a smaller animal than the type of *T. obscurus*, it is possibly a female, and is referred with confidence to a distinct species *Trilophodon simplicidens*. (2) The Florida type of *T. simplicidens* is also more brachyodont and (3) somewhat more primitive. (4) This type corresponds in dental evolution with the typical Middle Miocene specimens of *Trilophodon angustidens* of Simorre, France. The comparative measurements are as follows:

T. obscurus type, transverse across metalophid	72 mm.
T. simplicidens type, transverse across metalophid	60
T. obscurus type, transverse across tritolophid	71
T. simplicidens type, transverse across tritolophid	63
T. obscurus type, transverse across tetartolophid	62
T. simplicidens type, transverse across tetartolophid	55
T. obscurus type, height of tetartolophid	52
T. simplicidens type, height of tetartolophid	35

Trilophodon obscurus Leidy, 1869

Figures, 232, 233, 350C1, C2

Miocene (?), Greensburgh (Greensboro), Choptank formation, Caroline County, Maryland.

The real characters of the veritable type of *Mastodon obscurus* from Maryland are clearly shown in the original type figure (Fig 232), also in the new type figure (Fig. 233) prepared for this Memoir; the tooth is decidedly elongate and brachyodont with single central conules; the three crests preserved prove that it belongs to the *Trilophodon angustidens* phylum. If the protolophid were to be restored, this tooth would be relatively less narrow; it is more progressive than *T. simplicidens*, and less progressive than *Serridentinus productus* of the Upper Miocene.

GEOLOGIC AGE (SHATTUCK, MARYLAND GEOLOGICAL SURVEY, 1904, P. LXXVIII, PL. I, CHOPTANK STAGE).—Greensboro lies within the Choptank formation immediately above the Calvert formation, constituting the second member of the Chesapeake Group in Caroline and other counties of central Maryland (*op. cit.*, Pl. I); it contains a Miocene marine molluscan fauna. In this Maryland Geological Survey Miocene Memoir of 1904, Leidy's type of *Mastodon obscurus* is not mentioned. The Choptank formation may confidently be regarded (Shattuck, 1902, *op. cit.*, 1904, p. xl) as of Middle Miocene age.

Osborn, 1933: Final study of the veritable type of *Mastodon obscurus* Leidy proves that it does not belong in the genus *Serridentinus* Osborn, but in the related though distinct genus *Trilophodon*

[1](Osborn, 1935) This type, erroneously referred in 1923 to *Serridentinus*, now proves to be referable to *Trilophodon*.

Falconer. The phylogenetic position of *T. obscurus* appears to be distinct from the species *Mastodon (=Serridentinus) productus* of Cope and *M.* [*=Ocalientinus (Ser.)*] *floridanus* of Leidy.

We regard this animal as in a relatively simple stage of evolution as represented by the type molar tooth of *Mastodon obscurus*, which we have finally determined as the posterior portion of a third inferior molar of the left side, $l.M_3$ (see Fig. 232 reproduced from Leidy's Memoir of 1869). Great confusion has arisen in previous descriptions of *M. obscurus* owing to the fact that the specimens *referred* by Leidy to *M. obscurus* (Tarboro, N. C., Georgia, indeterminate locality) really belong to the distinct and much more progressive species of the Serridentinæ, i. e., *Ocalientinus (Ser.) obliquidens*; one of these progressive specimens (from Tarboro, N. C.), erroneously selected by Merrill (1907, p. 45) as the lectotype of *Mastodon obscurus*, actually belongs to *O. (S.) obliquidens* (Figs. 382, 384).

The type tooth is so important in the history of American palæontology that we give it the following very full description:

Mastodon obscurus Leidy, 1869. "The Extinct Mammalian Fauna of Dakota and Nebraska," etc., Journ. Acad. Nat. Sci., Phila., (2), Vol. VII, 1869, pp. 244, 396. TYPE.—Plaster cast of a *Mastodon* tooth (i.e., "Baltimore tooth") in the Museum of the Academy of Natural Sciences of Philadelphia (Phil. Acad.

ORIGINAL TYPE FIGURE OF TRILOPHODON OBSCURUS

Fig. 232. Original type figure of *Mastodon obscurus* Leidy, 1869, Pl. XXVII, fig. 13. Third inferior molar of the left side (cast Phil. Acad. 13278, cast Amer. Mus. 1909); one-half natural size. From Greensburgh, Caroline County, Maryland.

Observe the narrow, elongated form of this molar tooth, showing large external trefoils also rudimentary internal trefoils in two of the inner valleys.

13278, cast Amer. Mus. 1909), original lost, reputed to have been found in the Miocene formation of Maryland; recognized and labeled by Charlesworth as *M. longirostris* Kaup. TYPE FIGURE.—*Op. cit.*, 1869, Pl. XXVII, fig. 13. TYPE LOCALITY.—(*Op. cit.*, 1869, p. 244): "It was found at the depth of fifteen feet from the surface in a bed of marl near Greensburgh, Caroline Co., Maryland, and is considered by Mr. Lyell as a miocene fossil." (*Op. cit.*, 1869, p. 245, cf. Pl. XXVII, fig. 13) Intermediate in character between *M. americanus* and *M. angustidens;* present diameter sixty-eight lines, when perfect estimated at six and one-third inches; crown presents four transverse ridges and a heel, each ridge composed of inner and outer lobes, inner lobes with distinct trefoils, outer lobes simple.

LEIDY'S TYPE DESCRIPTION.—(*Op. cit.* 1869, p. 244): "In the collection [of Dr. Richard Harlan] I observed the plaster cast of a Mastodon tooth [Fig. 13], which struck me from its resemblance to a certain tooth of somewhat enigmatic character preserved in the Museum of this Academy. . . . Notwithstanding an extraordinary likeness, subsequent examination and comparison proved that the cast was derived from a different specimen. . . . The original of the cast is lost, . . . It was found at the depth of fifteen feet from the surface in a bed of marl near Greensburgh, Caroline Co., Maryland, and is considered by Mr. Lyell as a miocene fossil. . . . The original is also referred to by Dr. Warren, in his work on the *Mastodon giganteus* of North America, under the article headed 'The Baltimore Tooth,' page 78. . . . 'In the year 1843 a statement was made by Mr. Lyell on the miocene deposits of the United States, in which he noticed this tooth.' . . . . The cast, represented in figure 13, plate XXVII, is that of a last inferior molar of the left side, and indicates the tooth to have been intermediate in character with the corresponding teeth of *M. americanus* and *M.*

NEW FIGURE OF TYPE OF TRILOPHODON OBSCURUS

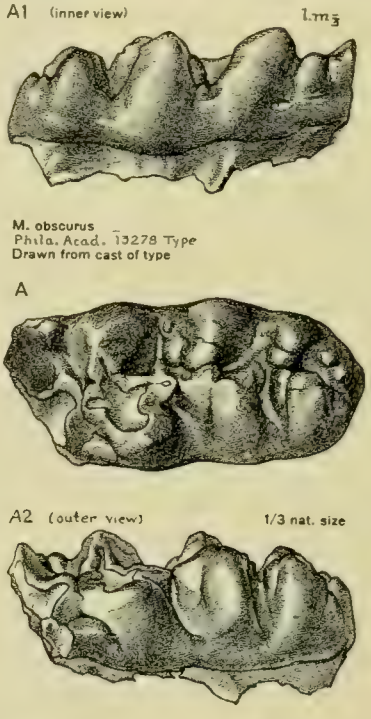


Fig 233. New *Mastodon obscurus* type figure, $l.M_3$, in three aspects, one-third natural size. After cast of type of *M. obscurus* (Phil. Acad. 13278, cast Amer. Mus. 1909) kindly loaned by the Academy. Observe that the protolophid is fractured and that the metalophid is the first complete crest exposed.

A, Crown view similar to that of Leidy's fig. 13 of Pl. XXVII. A1, Internal view showing rudimentary internal trefoils in the two anterior valleys. A2, External view showing central conules and external trefoils in three valleys.

angustidens. Fore and aft it is about the size of small specimens of teeth of the former species, but is proportionately narrower, and agrees better in this respect with those of the latter species. The crown presents four divisions or ridges and a heel, each of the former being composed in the usual manner of a transverse pair of lobes. . . . The fore and aft diameter of the cast in its present condition is sixty-eight lines, and when perfect is estimated to have been about six and one-third inches. . . . . The cast exhibits

so remarkable a resemblance in every respect with the representation of a tooth described by Prof. Owen in his History of British Fossil Mammalia, that it might readily be taken for a copy of the latter tooth."

Mistakenly Referred Specimens.—Leidy proceeds (*op. cit.*, p. 247) to describe another specimen (Tarboro), which he mistakenly regarded as of the same species [Fig. 16]: "Since writing the above, I have received for examination, from the Smithsonian Institution, two fragments of Mastodon teeth found at Tarboro, North Carolina. One is the posterior half of a last inferior molar, and is represented in figure 16, plate xxvii." This specimen proves to belong to the species *Ocalientinus* (*Ser.*) *obliquidens;* it was erroneously identified as the type of *Mastodon obscurus* by Merrill (1907, p. 45).

Osborn, 1932: This *Mastodon obscurus* type third inferior molar, $l.M_3$, known only from casts, has justified its specific name '*obscurus*'; only recently (December, 1932) has it been transferred by Osborn from *Serridentinus* to *Trilophodon* because of the presence of 'central conules' (new Fig. 233) and of 'central trefoils' in the second ridge-crest. *Trilophodon obscurus* is in a trilophodont stage of evolution similar to that of Cuvier's type of *Mastodon* [=*Trilophodon*] *angustidens* from Simorre, Middle Miocene of France (Cuvier, 1806.3, "Plate I, Divers Mastodontes"; Lartet, 1859, Pl. xiv, Figs. 1–4, *M. angustidens*).

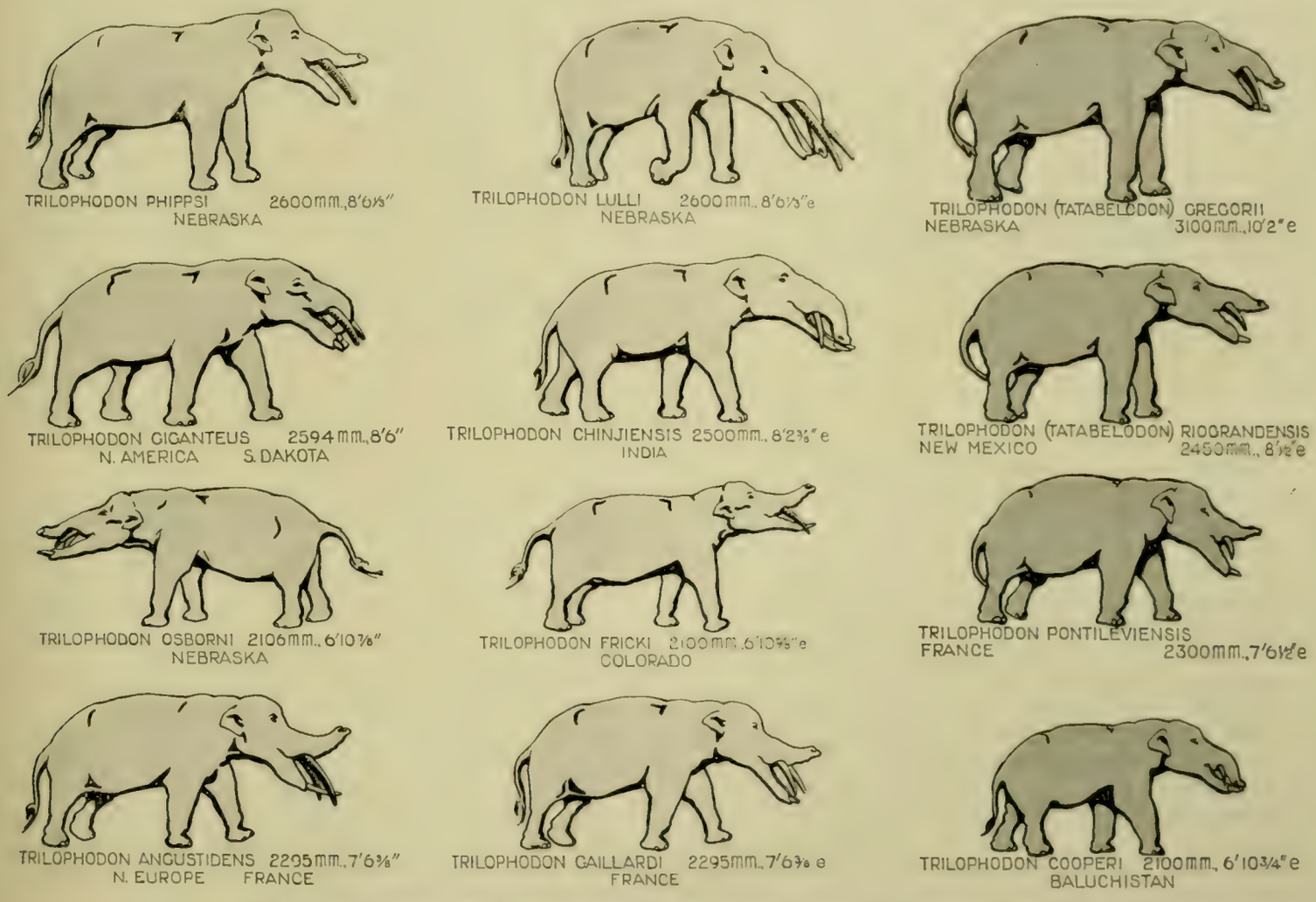


Fig. 234. Trilophodonts, Primitive and Progressive, of Eurasia and North America

One-hundredth scale

Restorations by Margret Flinsch, under the direction of Henry Fairfield Osborn

15. 'UPROOT-TUSKERS' OF KANSAS, NEBRASKA, SOUTH DAKOTA, COLORADO, AND NEW MEXICO, DESCRIBED BY ANDREWS, BARBOUR, COPE, MATTHEW, OSBORN, COOK, FRICK, AND PETERSON

That the remarkably long-jawed or hyperlongirostral Trilophodonts of America are closely related to the Miocene collective species *Trilophodon angustidens* of France and to the Trilophodonts of India is indicated not only in the extraordinary length of the lower jaw but in the simplicity of the third superior and inferior molar teeth; the latter, M_3, are four to five and a half crested, with prominent *central conules*; the breadth-length indices (as measured by Osborn) are from 40 to 45, the prevailing index being 40. The following valuable table of comparative measurements, omitting those of *T. morrilli*[1] [=*Eubelodon morrilli* of the present Memoir, see Chap. XII], was published by Cook in 1922, p. 8, in his description of "Two New Bunomastodonts from Colorado"; to this we add the measurements of *Trilophodon* (*Megabelodon*) *lulli*[2], *T. abeli*, and *T. fricki*.

	T. [*Amebelodon*] *hicksi*	*T.* [*Amebelodon*] *paladentatus*	*T. lulli*[2]	*T. osborni*	*T. abeli*	*T. fricki*
	mm.	mm.	mm.	mm.	mm.	mm.
Length of sixth molar, M_3....	199	174	222	190 [196]	185	172
Width of sixth molar, M_3.....	80	79	89	76 [80]	76	73
Breadth-length index of M_3..	40	45	40	40 [41]	41	42
Total length of mandible and tusk.....	1420	1482		1522[1525]	1359	1292
Total length of mandible without tusk.....	1050	910[3]	[1504[2]]	1346	1156	1134
Greatest width of mandibles across condyles.....	475	342	597	647	....	....
Transverse thickness of jaw under M_3.....	141	112	102	140	....	....
Greatest depth of jaw under M_3.....	150	151	206	....	190	....
Total length of symphysis....	460	438	724	483	470	492
Length of tusks beyond symphysis.....	380	485	....	249	216	132
Greatest width of lower tusks.	92	102	....	249	....	....
Greatest thickness of lower tusks.....	49	46	....	38	....	....
Length, bifurcation to condyles.....	585	572	788	....	....	....
Width of jaws through symphysis at large mental foramen.....	142	....	102	127	....	....
Depth at same point.....	160	155	127	152	....	....

The faunal assemblage is regarded as of Upper Miocene and Pliocene age (Fig. 188, p. 248). The geographic distribution of the types in chronologic order of their original description is as follows:

1. *Trilophodon dinotherioides* Andrews, 1909, northwestern Kansas. Strongly decurved lower jaw.
2. *Trilophodon* (*Genomastodon*) *willistoni* Barbour, 1914, Devil's Gulch, Niobrara River, Brown County, Nebraska. A *juvenile* type.
3. *Trilophodon* (*Megabelodon*) *lulli* Barbour, 1914, 1917, Snake River, Cherry County, Nebraska. Excessively long jawed.
4. *Trilophodon ligoniferus* Cope and Matthew, 1915, Black Hills, South Dakota. Anterior portion of jaw fragmentary.
5. *Trilophodon* (*Genomastodon*) *osborni* Barbour, 1916, Bristow, Boyd County, Nebraska. Young adult animal, long jawed.
6. *Trilophodon giganteus* Osborn, 1921, Eastview, near Dallas, Gregory County, South Dakota. A very large, long-jawed type.
7. *Amebelodon* (*Trilophodon*) *hicksi* Cook, 1922, Wray, Yuma County, Colorado. Fine jaws, moderately elongated.

[1]Genus *Eubelodon* Barbour, provisionally regarded as distinct from the Longirostrines and as related to the Humboldtines of South America.
[2]The *Trilophodon* (*Megabelodon*) *lulli* mandible lacks the incisive tusks. The original restorations and measurements (Figs 243, 244) were erroneous.
[3]Measurements approximate.

8. *Amebelodon* (*Trilophodon*) *paladentatus* Cook, 1922, Wray, Yuma County, Colorado. Excessively long jawed.
9. *Trilophodon abeli* Barbour, 1925, Devil's Gulch, Brown County, Nebraska. Perfect young adult jaw.
10. *Trilophodon pojoaquensis* Frick, 1926, Santa Fé marls, Santa Fé County, New Mexico.
11. *Trilophodon fricki* Peterson, 1928, Brown's Park formation, Moffat County, Colorado. A long-jawed type.
12. *Trilophodon phippsi* Cook, 1928, near Ainsworth, Brown County, Nebraska. A long-jawed type.

The theoretic phylogenetic order is treated in Section 17 of the present Chapter VIII. It is impossible to determine at present the specific resemblances and differences of these species; consequently they are all listed in chronologic order awaiting a final monographic revision which in turn will depend largely on a precise determination of the geologic horizons and levels in which the types occur.

All these trilophodont types of America appear to exhibit the following chief characters in common: (1) Hyperlongirostral; lower jaw extremely elongate, horizontal, or slightly deflected (*T. dinotherioides*). (2) Third inferior molars consisting of four transverse ridges and a posterior lobe or rudimentary pentalophid, progressive, with cement (*T. dinotherioides*); five transverse ridges and a rudimentary sixth ridge, hexalophid (*T. hicksi*[1]); (3) single *central* trefoils in superior and inferior molars, on median side of internal and external lobes respectively. (4) Third inferior molars long and narrow, prevailing breadth-length index 40 (45 in *T. paladentatus*[1], 36 in *T. dinotherioides*). (5) Length and breadth of third inferior molars, minimum (*T. paladentatus*) length 174 mm., breadth 79 mm., maximum (*T. lulli*) length 222 mm., breadth 89 mm. (6) Inferior incisive tusks elongate, flattened, horizontal or inturned so as to face each other, e.g., *T. giganteus*, *T. dinotherioides*, *T. paladentatus*. (7) While *single trefoils prevail* (*T. willistoni*), progressive *double* trefoils are observed (*T. osborni*, Fig. 249, *T. giganteus*, Fig. 259, *T. hicksi*, Fig. 260, *T. dinotherioides*, Fig. 236). (8) Median conules, *Phiomia osborni* Fig. 185, *T. osborni* (Fig. 252).

Synopsis of Mandibular Characters in American Trilophodonts and Amebelodonts

1. *Trilophodon dinothericides* Andrews, 1909, northwestern Kansas. Type lower inferior ramus, imperfect anteriorly, strongly decurved. Stage aged; M_2 shed, M_3 well worn, with four and a half to five crests. Cement. Rudiments of double trefoils on proto- and metalophids. Meas.: M_3, ap. 240 mm., tr. 87 mm., index 36. 'Oblique-tusker.'
2. *Trilophodon* (*Genomastodon*) *willistoni* Barbour, 1914, Devil's Gulch, Brown County, Nebraska. Juvenile type skull and jaws, in milk dentition. Stage juvenile. Jaws moderately elongated, medilongirostral. 'Prod-tusker.'
3. *Trilophodon* (*Megabelodon*) *lulli* Barbour, 1914, Snake River, Cherry County, Nebraska. Genotype of *Megabelodon*. Type skull and jaws, extremely aged; M_2 shed, M_3 extremely worn, with three and a half crests (*fide* Barbour, 1927). Meas.: M_3, ap. 222 mm., tr. 89 mm., index 40. Tuskless bony rostrum of jaw extremely elongated.
4. *Trilophodon ligoniferus* Cope and Matthew, 1915, Black Hills, South Dakota. Type incomplete lower jaw. Stage adult: M_1 shed, M_2 deeply worn, M_3 large, with four and a half to five crests; lophs elevated (hypsodont). Ramus slightly decurved. Meas.: M_3, ap. 245 mm., tr. 92 mm., index 38. Rudiments of double trefoils. (?) 'Oblique-tusker.'
5. *Trilophodon* (*Genomastodon*) *osborni* Barbour, 1916, Bristow, Boyd County, Nebraska. Genotype of *Genomastodon*. Stage young adult; second and third superior and inferior grinders in function, M^{2-3}–M_{2-3}; third lower molar, M_3, with $\frac{4}{4\,1/3}$ crests; third superior and inferior molars with *rudiments* of double trefoils (*tr. c.*, Fig. 249). Meas.: M_3, ap. 190 [196] mm., tr. 76 [80] mm., index 40 [41]. 'Prod-tusker.'
6. *Trilophodon giganteus* Osborn, 1921, Eastview, near Dallas, Gregory County, South Dakota. Type jaws and skeleton. Stage young adult; M_2, M_3 in full function. Jaws elongated, slightly decurved. Third inferior grinders with four and a half to five crests. Rudiment of double trefoil on tetartolophids only (*i. tr.*, Fig. 259). Meas.: M_3, ap. 172 mm., tr. 91 mm., index 53. 'Oblique-tusker.'
7. *Amebelodon* (*Trilophodon*) *hicksi* Cook, 1922, Wray, Yuma County, Colorado. Stage aged adult; M_2 shed, M_3 greatly worn, with five and a half crests. Ramus moderately elongated; lower incisors greatly elongated. Rudiments of double trefoils on meta-, trito-, and tetartolophids (see Fig. 260). Meas.: M_3, ap. 199 mm., tr. 80 mm., index 40. 'Shovel-tusker.'
8. *Amebelodon* (*Trilophodon*) *paladentatus* Cook, 1922, Wray, Yuma County, Colorado. Type very aged lower jaw, anterior portion broken, lower tusks greatly elongated. Stage extremely aged; M_3 alone functioning, with four crests. Meas.: M_3, ap. 174 mm., tr. 79 mm., index 45. 'Shovel-tusker.'

[1] *Trilophodon hicksi* and *T. paladentatus* ancestral to *Amebelodon*.

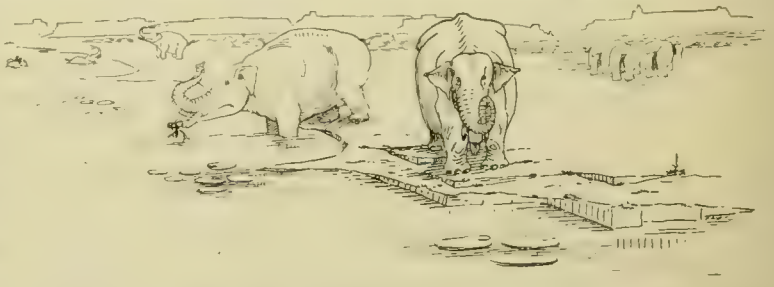
9. *Trilophodon abeli* Barbour, 1925, Devil's Gulch, Brown County, Nebraska. Type perfect young adult jaw, M_2, M_3 in full function. Bony ramus elongated, slightly decurved. M_3 with four and a half crests. Meas.: M_3, ap. 185 mm., tr. 76 mm., index 41. Double trefoil rudiments. 'Prod-tusker.'
10. *Trilophodon pojoaquensis* Frick, 1926, Santa Fé marls, New Mexico. Portion of left maxilla and adjacent region containing M^2, M^3 in full function, also both tusks; left tusk decurved; M^3 with four and a third crests. Meas.: M^3, ap. 197 mm., tr. 100 mm., index 51. Young adult stage. 'Prod-tusker.'
11. *Trilophodon fricki* Peterson, 1928, Brown's Park formation, Moffat County, Colorado. Greater portion of skull and lower jaws found interlocked in normal position; ribs and limb bones of an adult, but not old, individual; M_3 with 3¾–4 crests. Meas.: M_3, ap. 172 mm., tr. 73 mm., index 42. 'Prod-tusker.'
12. *Trilophodon phippsi* Cook, 1928, from near Ainsworth, Brown County, Nebraska. Associated skull and jaws, and essentially complete skeleton. M_3 with 4+crests. Meas.: M_3, ap. 232 mm., tr. 82 mm., index 35. Tuskless.

We owe to Prof. Erwin H. Barbour the discovery and description of the finest types of American trilophodonts. To the following five types he gave generic rank, namely:

Genomastodon Barbour, 1917, based on *Tetrabelodon willistoni, T. osborni.*
Megabelodon Barbour, 1914, 1917, based on *Tetrabelodon lulli.*
Mastelephas Barbour, 1917, without definition or specified type.
Amebelodon Barbour, 1927, based on *Amebelodon fricki.*
Torynobelodon Barbour, 1929, based on *Torynobelodon loomisi.*

Genomastodon.—(Barbour, 1917, p. 511): "As stated in previous articles, little doubt remains that the long-jawed mastodons from our northern tier of counties [i.e., of Nebraska] constitute a distinct group of proboscideans. For some time we have called this group the genomastodons in allusion to their grotesquely elongated 'chins' or jaws. Longirostral mastodons seem to have reached their maximum in such forms as Tetrabelodon willistoni, lulli, osborni, and the like. For the present at least, the above may be grouped under a new and distinct genus, Genomastodon [Footnote: 'Geno γενος chin, mast μαστος nipple, odon ὀδούς tooth']."

Megabelodon.—(Barbour, 1917, p. 511): "In the case of Tetrabelodon lulli, the sub-generic title *Megabelodon* [Footnote: 'Barbour, Erwin H. A New Longirostral Mastodon from Cherry County, Nebraska. Vol. 4, Pt. 14, Bull. 36, page 217.'] was proposed, but it seems entitled to higher rank. It is well-advised, wherever possible, to adhere, by means of suitable prefixes and suffixes, to such familiar and well-established words as Elephas and Mastodon, which have found their way into common speech. Tetrabelodon, meaning four-tusker is also a significant and definitive term, which is finding its way into current literature. The tetrabelodons of Europe differ so widely from those of America that it seems imperative to coin names for our Nebraska forms. It is interesting to note that between the genomastodons on the one hand and our mammoth on the other, there seems to be a very distinct intermediate group, which partakes at once, and equally, of the characteristics of Mastodon and Elephas. For this new intermediate group, we shall later propose the generic name *Mastelephas*, of which some 5 or 6 species, represented in the Nebraska State Museum, are being figured and described. These are distinct from the stegodonts."



Trilophodon (Genomastodon) osborni

Fig. 235. "Conjectural restoration of Tetrabelodon osborni." After Barbour, 1917, p. 512, fig. 12.

Amebelodon Barbour. 'Shovel-tuskers' characterized on pages 226, 328, and fully described and figured in Section 18, pages 333–338 below.

Osborn, 1926: Now that the American types of species are so closely connected up with the *Trilophodon* types of India and of western Europe, as figured above in this chapter, we do not find clear generic distinctions to validate the term *Genomastodon*. *Trilophodon* (*Megabelodon*) *lulli* is subgenerically distinct.

Trilophodon dinotherioides Andrews, 1909

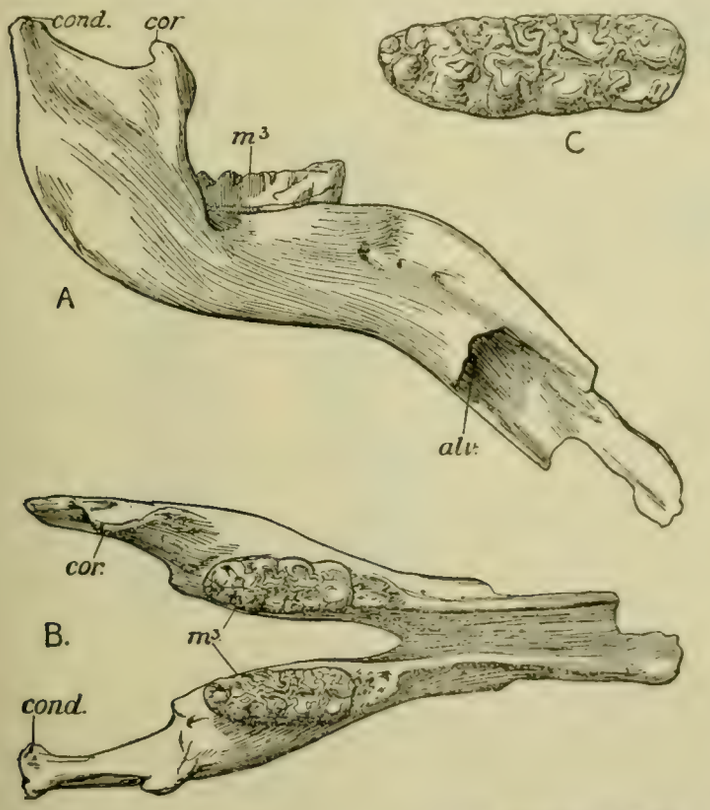
Figures 188, 236, 453

Northwestern Kansas, Lower Pliocene.
Compare with *Trilophodon* (*Genomastodon*) *willistoni* Barbour, 1914.

The grinding teeth of this animal compare with those of the typical *Trilophodon*. The sharper decurvature of the jaw and the lateral compression of the lower incisor teeth suggest *Rhynchotherium;* the length of the jaw, however, precludes the reference of this type to *Rhynchotherium*. It is a progressive 'oblique-tusker.'

Tetrabelodon dinotherioides Andrews, 1909. "Note on the Mandible of a New Species of *Tetrabelodon* from the Loup Fork Beds of Kansas." Geol. Mag., N.S., Dec. V, Vol. VI, 1909, pp. 347–349. TYPE.—A fairly complete mandible, "the upper portion of the ascending ramus being wanting on the left side, while on the right the articular condyle is much worn. The symphysial region also is imperfect, the outer walls of the sockets of the great lower tusks being broken away, while the extremity also is missing, the symphysis when complete probably having been considerably longer." HORIZON AND LOCALITY.—Collected by Mr. C. H. Sternberg in the Loup Fork beds of northwestern Kansas. Brit. Mus. M.9778. TYPE FIGURE.—Andrews, *op. cit.*, p. 348.

TYPE CHARACTERS.—(1) The most striking character is the long, massive symphysis, deflected to a greater extent than in any other *Tetrabelodon*, though considerably less so than in *Deinotherium*. (2) The spout-like upper surface of the symphysis is narrow and deep posteriorly, its concavity being about a semicircle; in this region its alveolar edges are comparatively thin and sharp. (3) Lower tusks very large, the vertical diameter of their roots (11 cm.) exceeding the lateral diameter. (4) The last molars, M_3, consist of four transverse ridges and a posterior lobe, each composed of an outer and inner cone. (5) Outer tubercles with a trefoil pattern, while the inner tubercles are imperfectly divided into an inner and an outer portion. (6) Tendency to alternation of the internal and external cones or tubercles. (7) Cingulum developed on the outer side of the tooth, opposite the openings of the transverse valleys. (8) Crown low, but thickly covered with cement which nearly fills the valleys. (9) Distinguished from *T.* [= *Rhynchotherium*] *euhypodon* by the greater deflection of the symphysial region and the larger number of ridges in the last lower molar.



Mandible of *Tetrabelodon dinotherioides*, sp. nov., Andrews, from the Loup Fork Beds, North-Western Kansas.

A. Right side of mandible, $\frac{1}{12}$ nat. size.
B. Upper view of entire mandible, $\frac{1}{12}$ nat. size.
C. Upper view of third right lower molar, $\frac{1}{6}$ nat. size.

alv. = alveolus of tusk; *cond.* = condyle; *cor.* = coronoid process; m^3 = third lower molars.
Drawn from original specimen in the Geological Department, British Museum (Natural History).

TYPE OF TRILOPHODON DINOTHERIOIDES

Fig. 236. Type figure of *Tetrabelodon dinotherioides* Andrews, 1909, p. 348. Brit. Mus. M.9778. A, B, one-twelfth natural size; C, one-sixth natural size. Observe lateral compression of mandible and tusks.

MEASUREMENTS

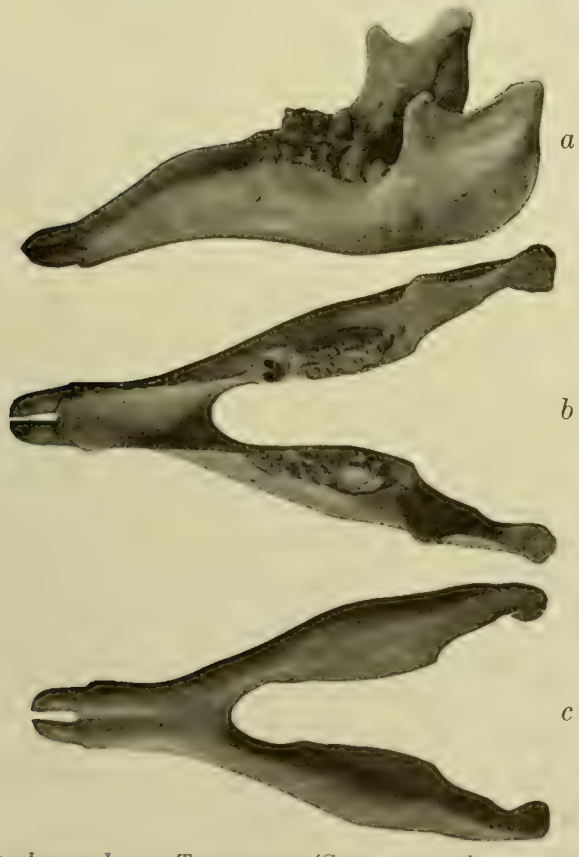
	Mm.
Length of last lower molar	240
Width of last lower molar	87
Length from condyle to tip of symphysis (approx.)	1265

This important type described by Andrews in 1909 apparently belongs in the *Trilophodon* phylum, because: (1) The third inferior molars consist of four tranverse ridges and a posterior lobe or pentalophid; (2) the outer lobes present a single trefoil; (3) the crown is brachyodont and thickly covered with cement which nearly fills the valleys; (4) the measurements and indices of the third inferior molars, namely, ap. 240 mm., tr. 87 mm., index 36, are similar to those in other Trilophodonts; (5) the incisor teeth are turned laterally, tending to face each other, a tendency also observed in the *T. giganteus* type.

Osborn in 1921 was at first inclined on account of the decurvature of the jaw to regard this animal as related to *Rhynchotherium*, but it is readily distinguishable from any member of the *Rhynchotherium* series by the very long, narrow proportions of the third inferior molar teeth which in all the Rhynchorostrinæ are relatively short and broad. It is distinguished from members of the *Tetralophodon* phylum by the presence of single trefoils, by the brachyodonty of the molars, and by the presence of four and a half to five crests in the third inferior molars, which are highly distinctive of all the members of the *Trilophodon* phylum. Consequently we place it in this phylum. The marked deflection of the lower jaw and the

TYPE SKULL OF TRILOPHODON (GENOMASTODON) WILLISTONI. A PRIMITIVE 'PROD-TUSKER'

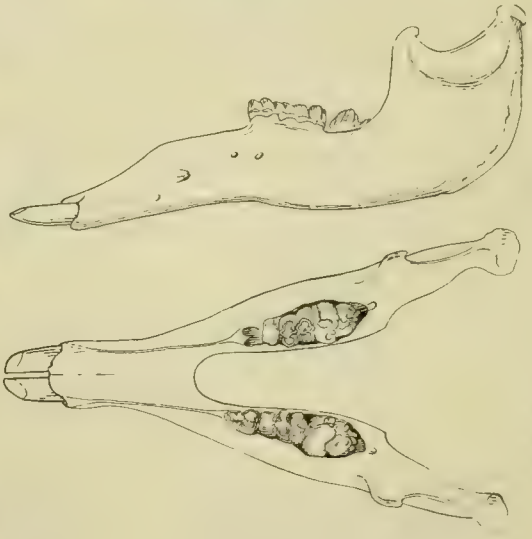
Fig. 237. Juvenile type skull and jaws of *Tetrabelodon willistoni* Barbour, 1914.1, Pls. v and vi, one-tenth natural size. Neb. Mus. 2-16-5-13. From Devil's Gulch A, Nebraska; probably of Lower Pliocene age.



TYPE LOWER JAW OF TRILOPHODON (GENOMASTODON) WILLISTONI

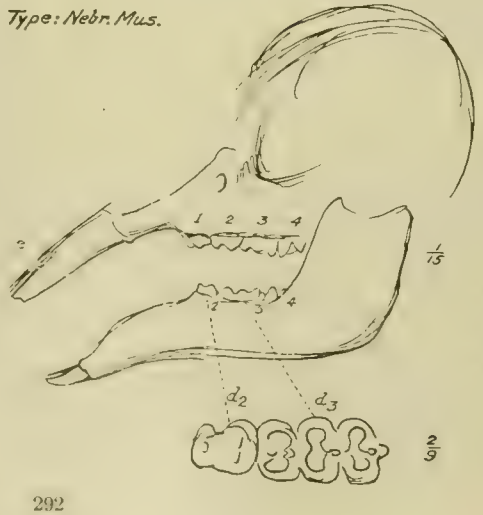
Fig. 238. Juvenile type lower jaw of *Tetrabelodon willistoni* Barbour, 1914.1, Pl. VIII, one-tenth natural size. Neb. Mus. 2-16-5-13. From Devil's Gulch A, Nebraska. "*Tetrabelodon willistoni*. *a*, mandible showing slightly decurved [rostrum and] symphysis; deep groove, and two strong tusks; molars 2, 3, 4; strong ascending rami; relatively high condyles and coronoids, and a pronounced sigmoid notch. *b*, top view. *c*, bottom view."

If this young jaw belonged to a true *hyperlongirostrine*, it would have increased rapidly in length as the animal grew older.



TYPE LOWER JAW OF TRILOPHODON (GENOMASTODON) WILLISTONI

Fig. 239. Type juvenile lower jaw of *Tetrabelodon willistoni* Barbour (Neb. Mus. 2-16-5-13), after original sketch by Professor Barbour. (Compare Barbour, 1914.3, p. 216, fig. 2.)



TYPE OF TRILOPHODON (GENOMASTODON) WILLISTONI

Fig. 240. Juvenile type of *Tetrabelodon willistoni* Barbour (Neb. Mus. 2-16-5-13). After pencil sketch by Osborn. Compare Barbour, 1914.1, p. 193: "The teeth are trilophodont. Those of the upper jaw are four in number, of the lower, three. All of the '*Tetrabelodon*' teeth found on this level seem to be small."

Observe that the trefoil conules are directly in the center of the valleys.

compressed condition of the fangs of the lower incisor teeth give the species *Trilophodon dinotherioides* a rather aberrant character. The presence of cement indicates that it is the most progressive member of the *Trilophodon* series thus far discovered. The four and a half to five crests of the lower molars are less progressive than the lower molars of *Amebelodon* (*Trilophodon*) *hicksi* (Fig. 260). Incisive tusks vertically expanded.

Trilophodon (Genomastodon) willistoni Barbour, 1914

Figures 172, 188, 237–241

Lower levels (A) of Devil's Gulch deposit, Niobrara River, Brown County, Nebraska; Lower Pliocene.

The genus *Genomastodon* Barbour, 1917, named in reference to its elongated and slightly deflected chin or rostrum (Fig. 238) is here regarded as synonymous with *Trilophodon* Falconer. A primitive 'prod-tusker.'

Juvenile Type.—We are very fortunate in the discovery and description by Prof. E. H. Barbour of the juvenile characters of a typical *Trilophodon*. The type of '*Tetrabelodon*' *willistoni* Barbour is a young male skull with the complete milk dentition *in situ* and the first superior molar. (1) The grinding teeth of the type include Dp^2-Dp_2, Dp^3-Dp_3, Dp^4-Dp_4, M^1. (2) The structure of these intermediate teeth is trilophodont, with single trefoils as in *Serridentinus productus*. (3) The ridge formula is: Dp $2\frac{1}{2}\frac{1/2}{2}$, Dp $3\frac{2}{3}\frac{1/2}{3}$, Dp $4\frac{3}{3}$, M $1\frac{3}{7}$. It is difficult to determine from this very immature specimen whether this specific stage is the same as one or other of the adult hyperlongirostrines subsequently described by Barbour and Osborn.

History.—Barbour originally (1914.1, pp. 192–194) described this type as *Tetrabelodon willistoni*; subsequently (1917, p. 512) he wrote: "Longirostral mastodons seem to have reached their maximum in such forms as Tetrabelodon willistoni, lulli, osborni, and the like. For the present at least, the above may be grouped under a new and distinct genus, Genomastodon." Thus by the elimination of *Tetrabelodon lulli*, *T. willistoni* becomes the first genotypic species of the genus *Genomastodon:* Geno γενος chin, mast μαστος nipple, odon ὁδούς tooth.

Tetrabelodon willistoni Barbour. 1914. "Mammalian Fossils from Devil's Gulch." Univ. Studies, Univ. Neb., Vol. XIV, No. 2, April, 1914, pp. 192–194. Type Skull and Jaws [Juvenile].— . . . "a nearly perfect skull with mandible, one cervical vertebra and numerous ribs, . . . The skull lacks parts of the zygoma, one exoccipital, part of the other, and the basioccipital. The mandible is without blemish." Museum, University of Nebraska, No. 2–16–5–13. Horizon and Locality.—Lower Pliocene; lower levels (A) of Devil's Gulch deposit, Niobrara River, Brown County, Nebraska. Type Figure.—*Op. cit.*, Pls. v, vi, and viii.

Type Description.—(*Op. cit.*, Barbour, 1914.1, p. 192): "This species, consisting of a nearly perfect skull with mandible, one cervical vertebra and numerous ribs, was found in Quarry No. 2, about 115 feet below the general level, 75 feet below, and about 300 feet distant from Quarry No. 1. This species is named for Dr. S. W. Williston. The skull lacks parts of the zygoma, one exoccipital, part of the other, and the basioccipital. The mandible is without blemish. The skull is narrow, and with inferior dome. The occiput, though slightly convex, is noticeably flat, and is furrowed but little along the median line. There is a well-marked, though broad, occipital crest. . . . Though not an adult, the air cells in the skull of *Tetrabelodon willistoni* are small, and the inflation moderate. It seems intermediate between the more typical ancestral forms and the later extreme forms. . . .The upper tusks curve downward and diverge at the tips, and on the outer side is a

Fig. 241. Left humerus (one-tenth natural size) and five tusks showing varying widths of enamel bands, *referred* to *Tetrabelodon* [=*Trilophodon*] *willistoni* Barbour, Devil's Gulch A, Nebraska. After Barbour, 1914.1, Pl. xiii, figs. f, g, h.

relatively broad, flat, enamel band, resting upon the dentine and presenting distinct edges. . . . The teeth are trilophodont. Those of the upper jaw are four in number, of the lower, three. All of the '*Tetrabelodon*' teeth found on this level seem to be small. In the upper molars, the outer tubercles are long and conical, with light cingulum, and with no secondary cones to fill the valleys. On the inner side, however, the tubercles are crowded with secondary cones, the valleys obstructed, and the cingulum strong and serrated by conelets."

Description of Type Mandible.—(Barbour, *op. cit.*, 1914.1, pp. 193, 194): "The mandible is in a state of perfect preservation. Its length is 30 inches (762 mm.) and the extreme width across the condyles is 14½ inches (368 mm.). It is but slightly decurved, and has a deep lingual groove with sharp edges. The mandibular border rounds into the ascending ramus without angle. The ascending ramus is strong and relatively high. The condyle has a distinct neck, and stands 4 inches (102 mm.) above the grinding surface of the molars. The sigmoid notch is deep, and the coronoid high and prominent. It resembles the typical coronoid more closely than does any proboscidean with which the writer is familiar. The symphysial prolongation is 9 inches (230 mm.). Two strong mandibular tusks project 4 inches (102 mm.) from the jaw, and are 1⅝ inches (42 mm.) through. They are worn obliquely at the tips, as shown in the accompanying cuts. The upper tusks had dropped out, but the tip of one, found in close proximity, undoubtedly belongs to this skull. Numerous other tusks were found on this level, and all show pronounced enamel bands. This early proboscidean is neither as low-browed, nor as long-jawed as one might expect."

Geologic Level.—Collection of 1913, lower levels (A) of Devil's Gulch, south side of Niobrara River, Brown Co., Nebraska. Found in Quarry No. 2, about 115 feet below the general level, 75 feet below, and about 300 feet distant from Quarry No. 1. Recorded by Barbour as about 75 feet below the level of the type of *Eubelodon morrilli*.

Trilophodon (Megabelodon) lulli Barbour, 1914, 1917

Figures 188, 243–245

Lower (?) Pliocene, Snake River, Cherry County, Nebraska.

Megabelodon, genotypic species *Tetrabelodon* (s.g. *Megabelodon*) *lulli*, proves to be a valid subgenus or genus.

Osborn, 1935: As recently discovered, the extremely long, narrow symphyseal rostrum (Fig. 244), terminating in a tuskless 'spoonbill' expansion, proves that the original restorations with a pair of prod-like tusks (Barbour, 1914) were erroneous. With Professor Barbour's permission (Barbour, letter, July 24, 1935) these tusks have been routed out of his type figures, as reproduced herewith (Figs. 243, 244). The narrow tuskless mandible of *Trilophodon* (*Megabelodon*) *lulli* is shown in figure 245, page 297, to resemble that of *Trilophodon* (*Amebelodon*) *joraki* Frick (see Fig. 281 A).

The superb skull and jaws discovered by E. H. Barbour in western Nebraska in 1914 undoubtedly exhibit a marked progression beyond the Middle Miocene stages of *Trilophodon angustidens* of Simorre and Sansan and represent a Lower Pliocene stage, perhaps as recent as Middle Pliocene. The elongation of the rostrum, of the superior tusks, and of the straight, nearly horizontal lower jaw indicates an advanced stage of evolution but at the same time a close generic relationship to *Trilophodon*, although the fact that only the posterior molars function in the adult condition may justify the selection of this specimen as the type of Barbour's new genus *Megabelodon*. A generic character of importance is that the third inferior molar is not fully tetralophodont, consisting of three completely developed crests and a well-formed half crest; whereas in the typical *T. angustidens* stage of Simorre the third inferior molar is fully tetralophodont with a half pentalophid developed. Thus this animal is more progressive than *T. angustidens* in its hyperlongirostral evolution but is less progressive in the retarded development of the lophs. (Barbour, letter, March 26, 1927): "There are three full sized crests and what I take to be a fourth crest that

Fig. 242. Lower to Middle Pliocene Exposures of Devil's Gulch on the South Side of the Niobrara River, Brown County, Nebraska. Compare figures 272, 273, 274, and 568

After photographs by Morris Skinner

(Left) Looking east up Devil's Gulch: (1) = *Eubelodon morrilli* quarry on the north side of the Gulch; (2) = *Equidæ* quarry on the south side of Devil's Gulch, containing intermingled *Protohippus*, *Pliohippus*, *Hypohippus*, *Hipparion*.

(Right) Looking west down Devil's Gulch: (1) North side of Devil's Gulch showing the *Eubelodon morrilli* quarry of the University of Nebraska Expedition of 1913.

narrows a good deal and is ground on such a slant that it looks reduced in size."

HISTORY.—Barbour originally described (1914.3, p. 217) this specimen as *Tetrabelodon lulli*, but in the same paper stated that it might be given the subgeneric title of *Megabelodon*. In 1917, p. 512, he wrote: "In the case of Tetrabelodon lulli, the sub-generic title Megabelodon [Footnote: 'Barbour, Erwin H. A New Longirostral Mastodon from Cherry County, Nebraska, Vol. 4, Pt. 14, Bull. 36, page 217.'] was proposed, but it seems entitled to higher rank." Thus *Tetrabelodon lulli* becomes the genotypic species of the genus *Megabelodon* Barbour.

Tetrabelodon (s.g. *Megabelodon*) *lulli* Barbour, 1914. "A New Longirostral Mastodon from Cherry County, Nebraska." Neb. Geol. Surv., Vol. IV, Part 14, November 25, 1914, p. 217. TYPE AND LOCALITY.—(Barbour, *op. cit.*, 1914.3, p. 214): "The mastodon constituting the basis of this paper was found in the exposures bordering the Snake River in section 33, range 30 west, and township 32 north. The talus slope was strewn with fragments of the tusk and bone of a mastodon. This led the field party to search for the source of the bones higher up the canyon, where they found the mere tip of a tusk exposed in a cattle path. While unearthing this, certain associated bones were found, and finally the great mandible shown in the accompanying figures. It is assumed from the close association of these parts that they are related. Work in this quarry will be resumed later, in the hope of recovering the skull and other bones of this individual." (*Op. cit.*, p. 213) Collection, Nebraska Geological Survey, season of 1914, "notably the great mandible of a new longirostral mastodon from Cherry County [Nebraska], together with associated tusk and bones." Museum. University of Nebraska, No. 10–8–14. These geologic deposits are designated as the "Snake River stage" by Barbour (p 214). TYPE FIGURE.—Barbour, 1914.3, Pls. III, IV, V, and VI. The type is a very aged animal in which M^2-M_3 alone function

TYPE DESCRIPTION.—(Barbour, *op. cit.*, 1914.3, pp. 214–221): "The mandible is uncommonly large, and faultlessly preserved. Unfortunately, the very tip of the rostrum, together with any tusks which it may have borne, are wanting. The great length of the rostrum would, in itself, be sufficient to warrant the assumption that tusks were present in life.[1] The alveolus also suggests the probability of their presence, although of necessity they must have been slim."

"Measured from the condyle, the unbroken length of the mandible, as found in the quarry, exclusive of tip and tusks, is 52 inches (1,322 mm.). Three large fragments of the tip, found at the end of the mandible, when set in position, increase the length to about 56 inches (1,424 mm.). Its total restored length, including

TYPE SKULL AND JAWS OF TRILOPHODON (MEGABELODON) LULLI

Fig. 243. Aged type skull and jaws of *Tetrabelodon* (*Megabelodon*) *lulli* Barbour (Neb. Mus. 10-8-14), one-twentieth natural size From notes given by the author: "The skull is restored throughout and is modeled largely after the skull of *Tetrabelodon osborni*. The mandible and tusk, and fragments of the skull, were found together. Length of tusk (measured on the outer curve) 1,720 mm. (68 in.); diameter 126 mm. (5 in.)." Right upper tusk restored.

(1935)[1] *Trilophodon* (*Megabelodon*) *lulli* is now found to lack inferior tusks. The rostrum is expanded at the tips (see Barbour, 1934.2). A perfect juvenile rostrum (see Fig. 245) has been discovered recently (Barbour, letters, July, 1935) which resembles that of *Trilophodon joraki* Frick (Fig. 281A, p. 327).

[1]See footnote 2 on page 288.

TYPE OF TRILOPHODON (MEGABELODON) LULLI. ROSTRUM ORIGINALLY RESTORED WITH TUSKS

Length of mandible 1504 mm. (see page 288 above)

Fig. 244. Type figure of *Tetrabelodon* (*Megabelodon*) *lulli* Barbour. Five views of aged mandible, as originally restored in front of white dotted line (Neb. Mus. 10-8-14). After Barbour, 1914.3, Pls. III-VI. Type locality: Snake River, Cherry County, Nebraska, "Snake River stage." One-tenth natural size. Note (Barbour, letter, Oct. 22, 1932) resemblance to *Trilophodon phippsi* Cook.

the tusks, is 69 inches (1,754 mm.).[1] There is every probability that the length exceeded 6½ feet (2 full meters). Dr. Richard S. Lull, who examined this specimen, is undoubtedly right in believing the tusks, as restored, too short. Presumably they were two or three times as long as shown in the accompanying plates. Since, in any event, the length of the tusks must be assumed, a very moderate size was chosen. The powerful ascending ramus and more especially the large and prominent coronoid indicate much longer tusks. It is much larger than either of the Tetrabelodons, longirostris or angustidens, and is of different proportions. . . . For this new species, we wish to propose the name Tetrabelodon lulli, for Professor Lull. It is not unlikely that it is entitled to rank as a new subgenus at least, and it might not be amiss to propose the name Megabelodon."

"The rostrum of this new mastodon is greatly elongated and decurved. The rami are spread well apart by a curve, the convexity of which is outward; while in angustidens, the curve is inward. The lingual groove is 2 inches (51 mm.) deep, growing shallower toward the tip, and bounded on the sides by narrow, rounded edges. The ramus is massive and powerful, being 31 inches (788 mm.) from the bifurcation to the condyle. It is 8 inches (206 mm.) deep, and 4 inches (102 mm.) thick at the molars. Immediately back of the molars, the thickness increases to 5 inches (127 mm.). The symphysial prolongation cannot be less than 28½ inches (724 mm.). Where the elongated mental foramen enters the jaw, the depth of the mandible is 5 inches (127 mm.), and the thickness 4 inches (102 mm.), whereas in angustidens, it is about 4 by 5 inches, or broader than deep."

"The angle is prominent, though thin, and flares outwardly. The ascending ramus is very broad and erect, and rises well above the crown of the molars. Below the condyle, the condyloid process is constricted into a very distinct neck. The condyle is noticeably convex, and its dimensions are 4½ inches (114 mm.) transversely, by 2¾ inches (69 mm.) postero-anteriorly. The apex of the condyle is 7½ inches (191 mm.) above the crowns of the molars. The total outside distance across the condyles is 23½ inches (597 mm.), and across the coronoids 19 inches (483 mm.)."

"The mandible . . . is from an individual advanced in age. The teeth are worn flat and low, and are deeply cupped at each of the four transverse ridges. Two cones are discernible in each ridge, but no secondary cones are apparent. Contrary to the usual order, the teeth are ground with an inward and backward slant. The back slant on the last transverse ridge is noticeably steep. The molars are 8¾ inches (222 mm.) long, by 3½ inches (89 mm.) wide. The long, attenuated symphysis is an ancestral feature, and its maximum development appears to have been reached in Tetrabelodon lulli. The narrowed and reduced alveolus seemingly marks a decline in the mandibular tusks, which foreshadows the reduction and ultimate suppression of the prolonged rostrum itself. . . . The maxillary tusk found associated with the mandible of Tetrabelodon lulli is slightly decurved, and is 5½ feet (1,678 mm.) in length, and 4½ inches (114 mm.) in diameter. Unlike Eubelodon morrilli, the tusk has an enamel band, and the tip is worn to a very obtuse edge. The associated humeri seem uncommonly short, and stout. They are about 30 inches (762 mm.) in length. . . . In the case of the acetabula of Tetrabelodon lulli, the fossae are narrow and deep, and the heads of the femora have corresponding scars."

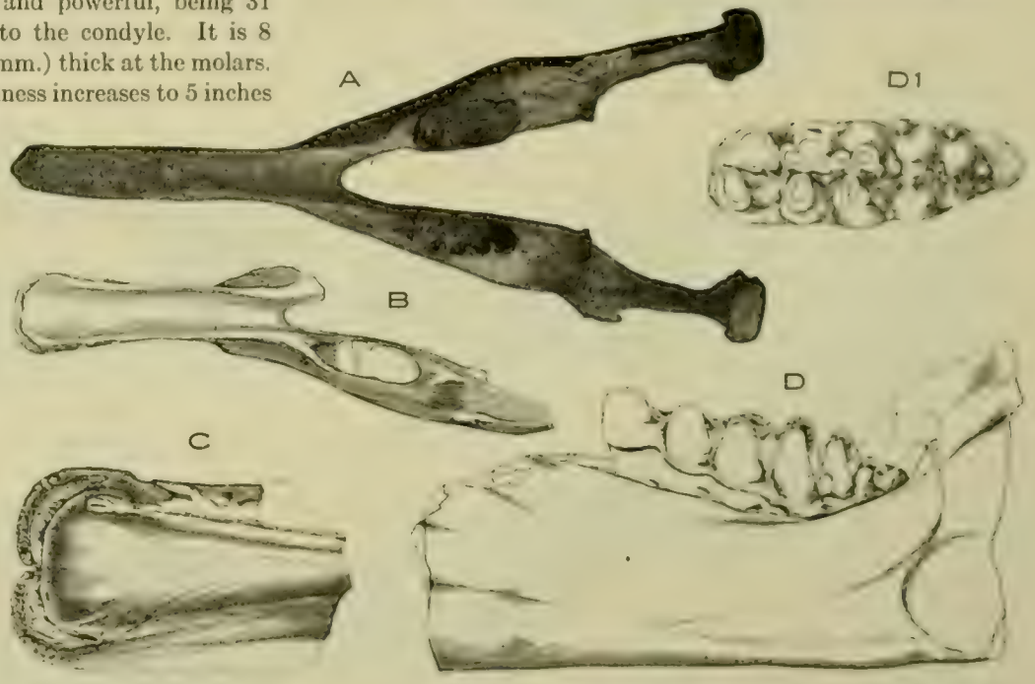


Fig. 245. (B) Frick's type of (?)*Amebelodon* [=*Trilophodon*] *joraki*, exhibiting the tuskless 'spoonbill' expansion of the symphyseal rostrum. (C) Recently discovered 'spoonbill' rostrum (Neb. Mus. 2-25-6-35 N. P.), also (D) portion of right mandible containing M_3 (Neb. Mus. 1-25-6-35 N. P.) and (D 1) crown view of M_3, referable to either *T. joraki* or *T.* (*Megabelodon*) *lulli*.

(A) Compare narrow mandibular rostrum of type (Neb. Mus. 10-8-14) of *Trilophodon* (*Megabelodon*) *lulli* (see Figs. 243, 244), also probably expanded at the tip.

Approximate scale: A, One-fifteenth; B, one-thirteenth; C, D, D 1, one-sixth natural size.

Osborn, 1921: This remarkable type, found on the Snake River some 3½ miles south of the Niobrara River, is readily distinguished as a typical Longirostrine, with the third superior molar in the three to four crested stage, apparently with single trefoils on the *inner* lobes of the upper molars and on the *outer* lobes of the lower molars. In the three and a half (?) to four and a half (?) crested stage the proportions of the much worn third inferior molar, as calculated by Barbour, are M_3, ap. 222 mm., tr. 89 mm., index 40. This is a very long, narrow tooth, the breadth-length index being as low as in the narrowest tooth from Sansan, namely, 39. A strong internal cingulum on M^3. M_3 is trilophodont, with an additional half crest. The superior tusks have a typical enamel band on the concave outer surface. The symphyseal portion of the ramus is greatly elongated and somewhat decurved.

[1]See footnote on page 288.

The breadth-length indices of the third inferior molar, M_3, in American Hyperlongirostrines, calculated from comparative measurements by Harold Cook, are as follows:

Type M_3	ap.	tr.	I.
Trilophodon (Megabelodon) lulli	222	89	40
Amebelodon (Trilophodon) hicksi	199	80	40
Amebelodon (Trilophodon) paladentatus	174	79	45
Trilophodon osborni	190[196]	76[80]	40[41]
Trilophodon abeli	185	76	41

Trilophodon ligoniferus Cope and Matthew, 1915

Figures 188, 246, 282

Black Hills of South Dakota, horizon uncertain, (?)Lower Pliocene.

This imperfectly known animal, mentioned in Cope's manuscript and unpublished plates as "*Mastodon ligoniferus,*" is represented by a jaw (Amer. Mus. Cope Coll. 8531). Its geologic level as well as its generic or phyletic position are uncertain, and in this Memoir it is provisionally regarded as a progressive or ascending mutation of *Trilophodon giganteus* Osborn (Figs. 259 and 282).

Cope-Matthew, 1915.—The name *Mastodon ligoniferus* was inscribed by Cope on Plates CXXII and CXXIV of his unpublished Memoir of the Geological and Geographical Survey of the Territories (see Cope and Matthew, 1915, Prefatory Note). In editing these plates Matthew determined the specimens and figures as above cited but did not define the species. We may assume that Cope recognized this as a distinct stage of evolution and that the publication by Matthew in 1915 of Cope's plates validates this name as applied to this type specimen (Amer. Mus. 8531). Consequently the systematic revision of this species is as follows:

Mastodon ligoniferus Cope, 1915. "Hitherto Unpublished Plates of Tertiary Mammalia and Permian Vertebrata." Cope and Matthew, 1915, U. S. Geol. Surv. by The American Museum of Natural History, Monograph Series No. 2. Type.—Lower jaw, Amer. Mus. Cope Coll. 8531. Type Locality.—Black Hills, South Dakota, horizon uncertain. No type description. The species rests upon Cope's Plate CXXIV, figs. 1 and 2, with the name "ligoniferus" underneath.

Specific Characters of T. ligoniferus (Osborn, 1924).—This animal appears to be an ascending mutation above *Trilophodon giganteus* Osborn, if we may judge by comparison of the type specimen reproduced from the Cope-Matthew Memoir (Fig. 246) and the comparative figures prepared for the present Memoir (Fig. 282, C, *T. giganteus*, G, *T. ligoniferus*), which show that in *T. ligoniferus* M_3 is the largest tooth, the most progressive tooth, the most hypsodont tooth of the series. This is also shown in the measurements and indices printed below in the description of *Serridentinus progressus*[1] which may be presented here in another form:

		ap.	tr.	I.		ap.	tr.	I.	
T. ligoniferus type (Amer. Mus. 8531)	M_2	121e	72	59e	M_3	245	92	38	M_{2-3}=360e
T. giganteus type (Amer. Mus. 17359)	M_2	140e	86	61e	M_3	172	91	53	M_{2-3}=305e
S. progressus type (Amer. Mus. 8529)	M_2 incomplete				M_3	201e	88	44e	M_{2-3}=304e

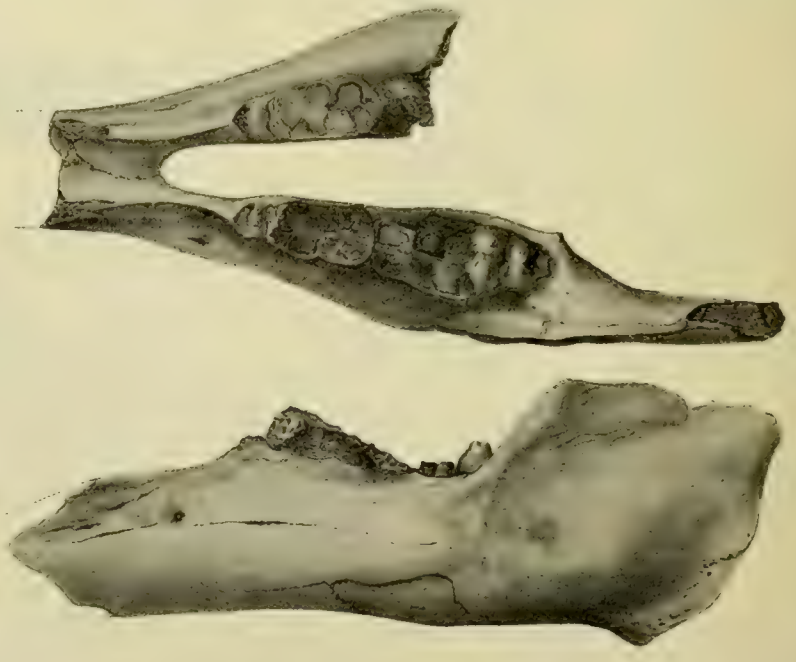
[1]Originally described by Osborn in 1923 as *Trilophodon progressus.*

Trilophodon (Genomastodon) osborni Barbour, 1916

Figures 188, 247–256, 280

Bristow beds; seven miles north and two east of Bristow, Boyd County, Nebraska, Lower Pliocene. (Barbour, 1917, p. 507): "In association with this specimen were teeth of three other individuals of unlike species, and the bones and teeth of horse (Protohippus and Hipparion), rhinoceros, camel, and rodent (Dipoides tortus)."

Osborn (1923-1927) is inclined to regard this as one of the most primitive Hyperlongirostrines found in America and nearest to the typical *T. angustidens* stage of evolution. The lower jaw undoubtedly would have elongated as the animal became more mature. This animal appears to be a young Longirostrine. The type specimen is a young adult with the second and third superior and inferior molars fully functional, M^2-M_2 being a little more worn than M^3-M_3. The ridge formula, namely, M 2 $\frac{3}{3}$, M 3 $\frac{4}{4\ 1/2}$, is in the same stage of evolution as in the typical *Trilophodon angustidens.* The third lower molar (Fig. 252) is similar in proportions to that of *Trilophodon obscurus.* The lower jaws are upcurved and remind us of those in the Paris Museum skull (Fig. 200). There are single trefoils on the inner lobes of the superior molars and on the outer lobes of the inferior molars, as shown in the accom-



Type of Trilophodon ligoniferus Cope and Matthew

Fig. 246. Type of *Mastodon ligoniferus* Cope and Matthew, 1915, Amer. Mus. Cope Coll. 8531. Reproduced after Cope and Matthew, *op. cit.*, Pl. CXXIV, figs. 1 and 2, one-eighth natural size. Lower jaw; superior and lateral views.

Plate CXXIV is designated by Cope and Matthew as follows: "Plate CXXIV . . . Cope 1880–3 . . . Mastodon ligoniferus . . . Figs. 1–2. . . . . Amer. Mus. No. 8531, Cope Coll. Black Hills, S. Dakota, horizon uncertain. Fig. 1. Lower jaw, external view; fig. 2, superior view; . . . All one-fourth natural size. The name *ligoniferus* appears to be unpublished."

panying sketches by the writer (Fig. 249); the inner faces of the upper molars are strongly convex and cingulate. The primitive feature is the trilophodont condition of M_2 in which a single cone represents the tritolophid, this crest being imperfectly developed.

History.—This fine specimen was originally described by Barbour (1916, pp. 522–529) as *Tetrabelodon osborni;* subsequently (1917, p. 512) he wrote: "Longirostral mastodons seem to have reached their maximum in such forms as Tetrabelodon willistoni, lulli, osborni, and the like. For the present at least, the above may be grouped under a new and distinct genus, Genomastodon [Footnote: 'Geno γενος chin, mast μαστος nipple, odon ὀδούς tooth']."

Type Mandible of Trilophodon (Genomastodon) osborni. Young adult. A 'Prod-tusker'

Fig. 247. Young adult type mandible of *Tetrabelodon osborni* Barbour, 1916, figs. 1, 2, 3. Neb. Mus. 30-6-15. From the "Bristow beds" east of Bristow, Boyd County, northern Nebraska. Reproduced from original photographs, one-tenth natural size.

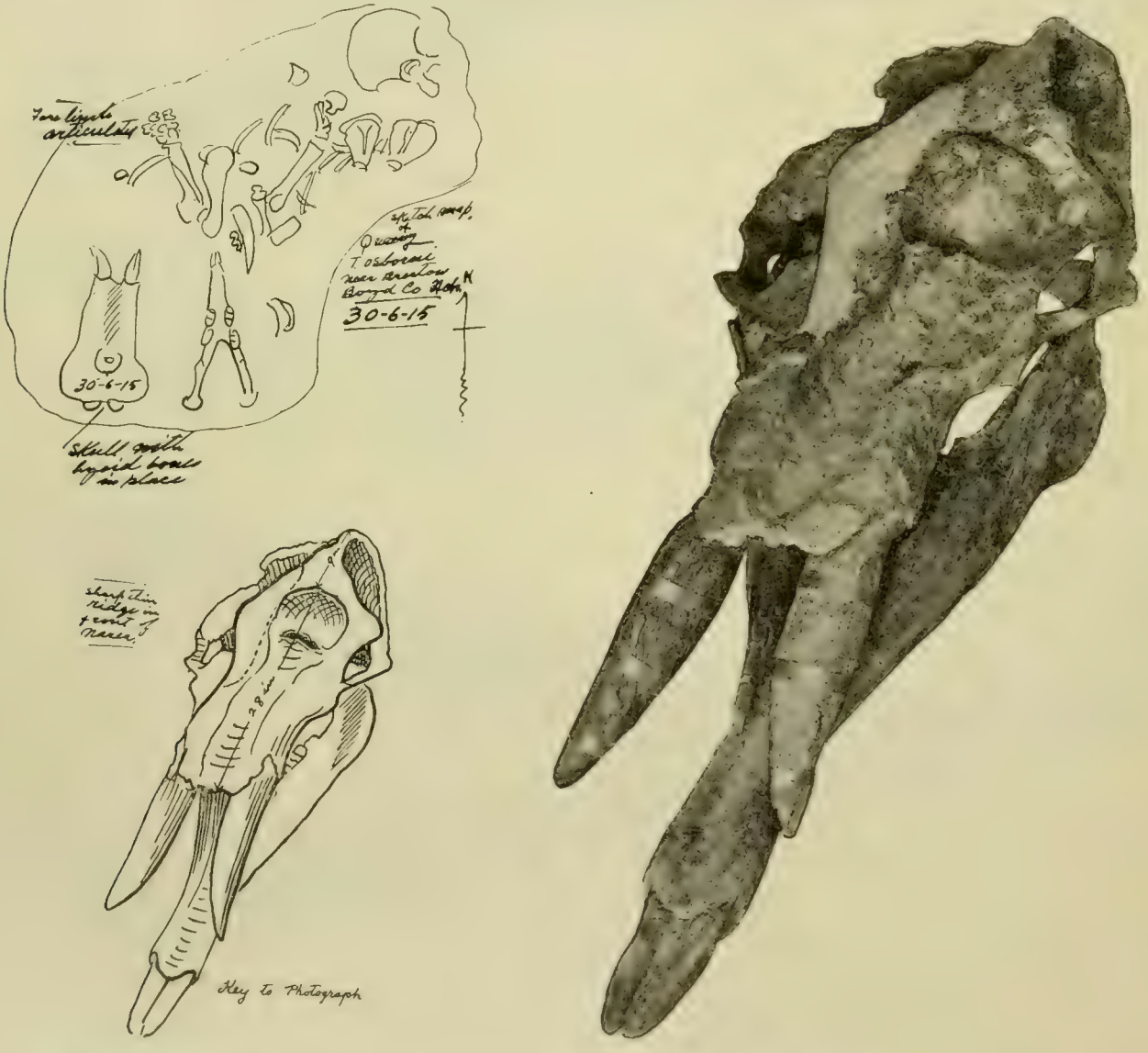
Observe that the ridge formula is: $M\,2\frac{}{3}\ M\,3\frac{}{4\,5}$, typical of *Trilophodon;* that the conules are in the center of the valleys; also that this young adult jaw is relatively much longer than in the juvenile type of *Trilophodon (Genomastodon) willistoni.*

Palæontology is indebted to Prof. E. H. Barbour for the discovery and description of this unique stage. The animal is shown (Fig. 255) to be extremely short and heavy limbed like all the known Hyperlongirostrines in America. The dental measurements and indices (letter, Barbour, January 10, 1923) are as follows:

M^2			M^3			M_3		
ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.
130	95	73	185	100	54	190[196]	76[80]	40[41]

The following is the author's description in full with type figures:

Tetrabelodon osborni Barbour, 1916. "A New Longirostral Mastodon from Nebraska, *Tetrabelodon osborni*, sp. nov." Amer. Journ. Sci., Vol. XLI, June, 1916, pp. 522–529. Type.—"The skull and mandible, though checked and fragile, were finely preserved, and one fore-limb had all of its elements, from scapula to manus inclusive, in position. The skull, mandible and hyoids, pelvis, scapulæ, and numerous ribs were close to the surface. Consequently they were checked to the extreme degree, and rootlets had found their way into the bones. It required extreme care in collecting to save this specimen. Certain bones, at a depth of three to seven feet, were harder and less checked." Nebraska State Museum No. 30–6–15. Type Locality.—"Running water gullied a pasture belonging to Mr. Z. T. Long, 7 miles north and 2 miles east of Bristow, Nebraska, and exposed a Tetrabelodon. . . . In company with Mr. C. Harold Eaton, the writer visited Bristow at once, and in less than a fortnight, the skeleton of a new Tetrabelodon, practically complete, was secured. The skeleton was exposed on a sloping hillside in channel gravels composed of



Type Skull and Skeleton of Trilophodon (Genomastodon) osborni

Fig. 248. Type skull and skeleton of *Tetrabelodon osborni*, Neb. Mus. 30-6-15, as found near Bristow, Boyd County, Nebraska. From pen sketches and measurements by E. H. Barbour. Photographic view of skull and mandible, as at present restored, after E. H. Barbour, one-tenth natural size.

three or four feet of very coarse, lime pebbles underlain by five or six feet of fine sand. The deposit is of Pliocene age equivalent to the Snake River of Cherry County, and the lower Devil's Gulch beds of Brown County. For convenience we shall call these the Bristow beds." TYPE FIGURE.—Barbour, *op. cit.*, 1916, p. 523, fig. 1; p. 524, fig. 2; p. 526, fig. 3; p. 528, fig. 4.

BARBOUR'S ORIGINAL DESCRIPTION OF TRILOPHODON OSBORNI

TYPE DESCRIPTION.—(Barbour, *op. cit.*, 1916, pp. 523–527): "For this new proboscidean, we wish to propose the name *Tetrabelodon osborni*, in recognition of Dr. Henry Fairfield Osborn. The peculiarities of the skull promise to be so great that eventually this specimen must be assigned to a new genus."

"In this Tetrabelodon a unique adaptation presents itself, and a new principle seems to be involved, namely, the use of the mandible and the mandibular tusks for work and defense. There is a suggestion in the protruding mandible and its strong, recurved tusks, that they may have functioned as a sort of shovel in digging and tearing up roots, aquatic plants, and the like. However this may be, the inferior tusks are well developed and modified, while the superior, though heavy, are short and seemingly useless."

"The mandible is long and very strong, the rami widely divergent, the angle thin and reflected, the symphysial portion relatively short, noticeably broadened and somewhat upturned at the tip. The lingual groove is moderately deep behind but shallow in front, and the walls converge from 5 inches posteriorly to 3 inches anteriorly and blend at once into the flattened, broadened tip. The ascending ramus is very oblique, the condyle large, the coronoid low, and the sigmoid notch shallow and straight. The length and leverage of this great jaw seem to call for broad, erect, ascending rami. Just back of the molars the jaw is thin, in front very thick. Anteriorly, the symphysis becomes broader than thick, unlike other forms in the Nebraska State Museum. The elongated mental foramen is close upon the inferior border. The inner alveolar border extends as a ridge well to the condyle."

"The jaw is that of an adult, but not an aged individual. Molars five and six are present and are fairly well worn. The fifth molar has three, while the sixth has four, transverse crests and a large heel. This heel, which is as well developed

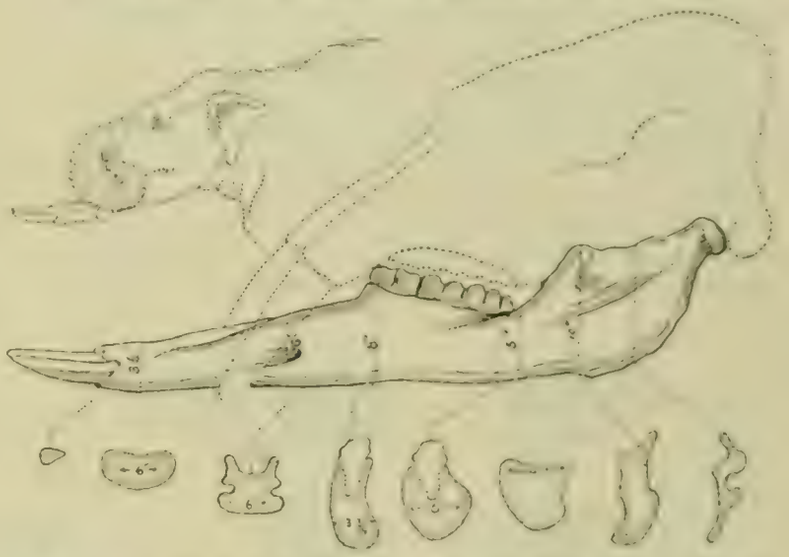


Fig. 250. Type figure of young adult skull and mandible of *Tetrabelodon* [=*Trilophodon*] *osborni* Barbour, 1916, fig. 4. One-fifteenth natural size.

"The skull is still in plaster 'cinches.' Below are shown sections of tusk and mandible. Above, a conjectural restoration of the head. 5" should read 5½"."

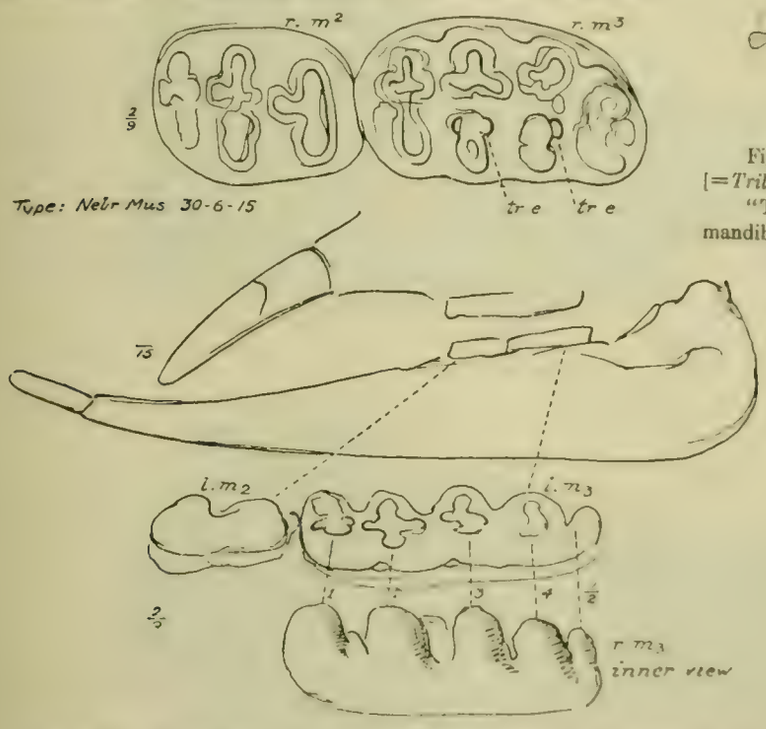


Fig. 249. Sketches by Osborn of the crown views of type superior and inferior grinding teeth of *Trilophodon* (*Genomastodon*) *osborni*, Neb. Mus. 30-6-15.

Right superior grinders, M^2, M^3, show complete *internal* trefoils, rudimentary external trefoils (tr. e.). Left lower grinders show complete *external* trefoils, rudimentary internal trefoils.

Fig. 251. "Fifth and sixth left lower [upper] molars, Tetrabelodon osborni, showing four ridges, a prominent heel and solitary central cones interrupting the valleys." After Barbour, 1917, p. 505, fig. 7. Type.

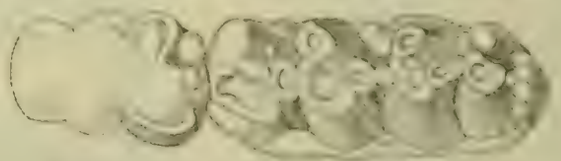


Fig. 252. "Fifth and sixth left upper [lower] molars, Tetrabelodon osborni, showing indistinct trefoils, and a pair of central conules in the valleys. No cement. After Barbour, 1917, p. 505, fig. 6. Type. Compare M_3 of *Phiomia osborni* (Fig. 185).

as the fifth ridge in *Mastodon americanus*, would have developed into a fifth crest by continued wear. Along the middle line of the tooth rise the accessory cones, regularly and mostly singly. Accordingly, the tooth is made up of alternating major and minor ridges. Excepting these alternating cones, the tooth is not unlike the sixth molar of *Mastodon americanus*. The cingulum is strong and broad. The sixth molar is 7⅓ inches (190 mm.) [7¾ inches (196 mm.)] long, 3 inches (76 mm.) wide through the cingulum, and has a grinding surface of 2 inches [51 mm.]. Where the teeth are broken, the dentine shows distinct decussation. The pattern of the worn crown is not distinctly trefoiled as are many of our Tetrabelodons. The teeth slant backward and inward. The low stature of the creature, 7 feet, and the long jaw, 5 feet, made it easy to reach the ground with the lower tusks. The inferior tusks are long and strong. They are imbedded the length of the symphysis and are about as long as the superior tusks, and protrude, at most, about 10 inches [254 mm.] out of the jaw. They are 1½ inches (38 mm.) thick and 2 inches (51 mm.) broad, and are produced into a dull edge laterally."

"The jaw and its tusks protruded more than [nearly] 2 feet (610 mm.) beyond the skull. It was a grotesque head on a grotesque body. The skull, still in plaster 'cinches,' is relatively short, about two-thirds that of the mandible, and the upper tusks very short and stout."

"Fortunately, both of the upper tusks are perfect and in place in the skull. They curve downward and outward and are produced to a distinct point and are somewhat flattened on the inner side. They are about 4 inches (102 mm.) in diameter and very short, for scarcely more than 16 or 18 inches (407 to 457 mm.) protrude beyond the incisive sheath, and still less beyond the flesh in life. . . . The articulated fore limb indicates an animal little more than 7 feet in height, half that of a large mammoth. The vertebræ

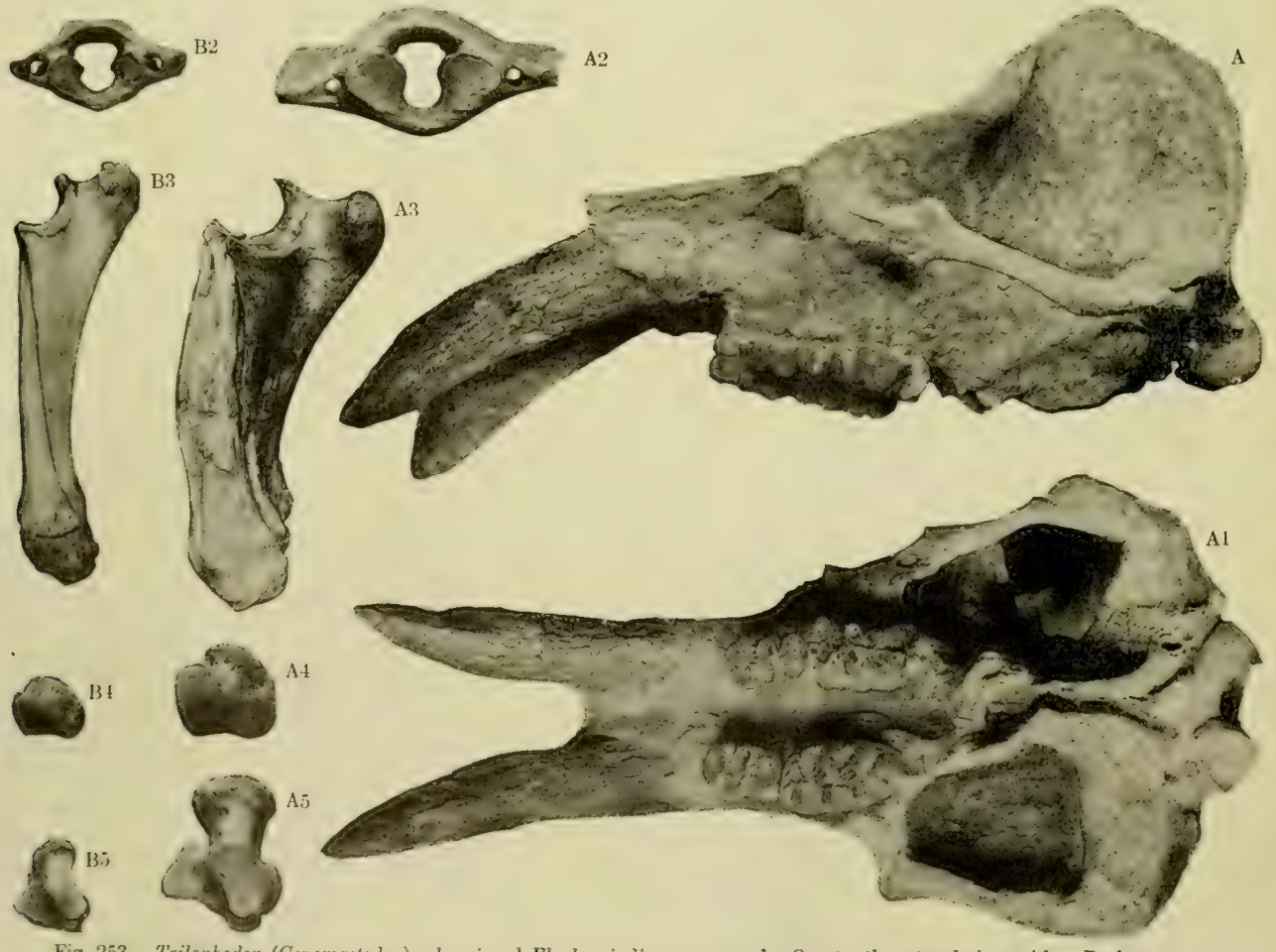


Fig. 253. *Trilophodon* (*Genomastodon*) *osborni* and *Elephas indicus* compared. One-tenth natural size. After Barbour.

A, After Barbour, 1917, p. 500: "Fig. 1.—Skull . . . of the Boyd County Mastodon, Tetrabelodon osborni, showing . . . low dome, slender zygomatic arch, short xiphoid tusks. Specimen perfect, barring frost cracks. . . . Palæontological collections of Charles H. Morrill and Hector Maiben, The Nebraska State Museum." Neb. Mus. 30-6-15.

A1, After Barbour, 1917, p. 501: "Fig. 2.—Skull of Boyd County Mastodon, Tetrabelodon osborni, palatine view, showing molars five and six, and short xiphoid tusks. Anatomically perfect and without restoration. The basi-cranial elements, palate, and incisive sheaths lie in the same plane." Neb. Mus. 30–6–15.

A2, Referred atlas, Neb. Mus. 26-7-16. A3, Type ulna and radius, Neb. Mus. 30-6-15. A4, Referred astragalus, Neb. Mus. 8-8-16 (reversed). A5, Referred calcaneum, Neb. Mus. 2-17-7-16.

B2–5, *Elephas indicus*, half grown individual. B2, Atlas. B3, Ulna and radius. B4, Astragalus. B5, Calcaneum.

seem large out of all proportion, being equal in size to those of the mammoth. This Tetrabelodon was short-legged, broad-hipped, heavy-bodied, and perhaps semi-aquatic in habit. Its body must have dragged close to the ground, not unlike *Teleoceras fossiger*, the short-legged rhinoceros."

MEASUREMENTS OF MANDIBLE.

	Inches	Millimeters
Length from condyle to tip of tusk	60	1522[1525]
Length exclusive of tusk	53	1346
Width across condyles, over all	25½	647
Length of symphysis	19	483
Width of symphysis at its tip	6	152
Width of symphysis at mental foramen	5	127
Thickness of jaw at 5th molar	8	203
Thickness of jaw back of 6th molar	5½	140
Thickness of jaw at tip	3	76
Thickness of jaw just back of mental foramen	6	152

MEASUREMENTS OF LIMB BONES.

	Inches	Millimeters
Scapula, along mesoscapular line	26	660
Length of humerus	26	660
Trochlear, width	8	203
Diameter across head and tubercle	9	229
Length of radius	22	559
Ulna, over all	24	610
Length of femur, about	30	762
Diameter of head	5	127
Across pelvis	60	1522[1525]

MEASUREMENTS OF SKULL.
(Still in plaster 'cinches.')

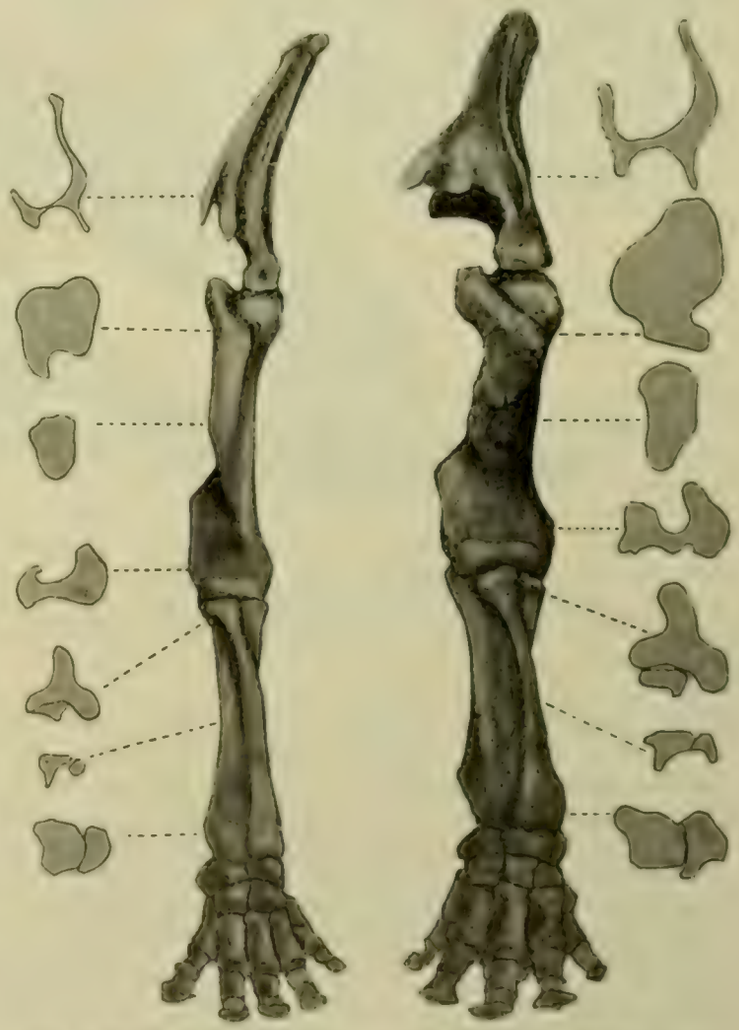
	Inches	Millimeters
Occipital condyles to tip of tusk, about	52	1320[1322]
Length of skull exclusive of tusks	36 to 38	915 to 965
Width of skull, about	28	710
Depth of skull, about	20	508

"The bones of the fore limbs are short and disproportionately heavy, while those of the hind limbs are short and relatively light. The scapula varies noticeably from the general proboscidean type. The prescapula seems to be reduced to a remnant in the lower half and to a mere ridge in the upper. The postscapula and mesoscapula are correspondingly developed. The mesoscapula extends as a stout, erect ridge to the suprascapular border. The humerus, radius and ulna, carpals, and phalangeals are noticeably short and extremely heavy."

BARBOUR'S SECOND DESCRIPTION (1917) OF THE SKULL OF TRILOPHODON OSBORNI

In the description (1916) cited in full above, a few measurements are altered or amplified from the second description of the skull (Barbour, 1917, pp. 499–512). The following supplementary notes and observations by Professor Barbour are important,

Fig. 254. "a, left upper tusk Tetrabelodon osborni, side view, supposedly female, showing enamel band etched by Daimenchix fibers. Found in pit near skull. Length, 19 inches (483 mm.), diameter, 3 inches (76 mm.), × ⅛; b, same, sectioned, to show xiphoid shape; c, same from above." After Barbour, 1917, p. 504, fig. 5.



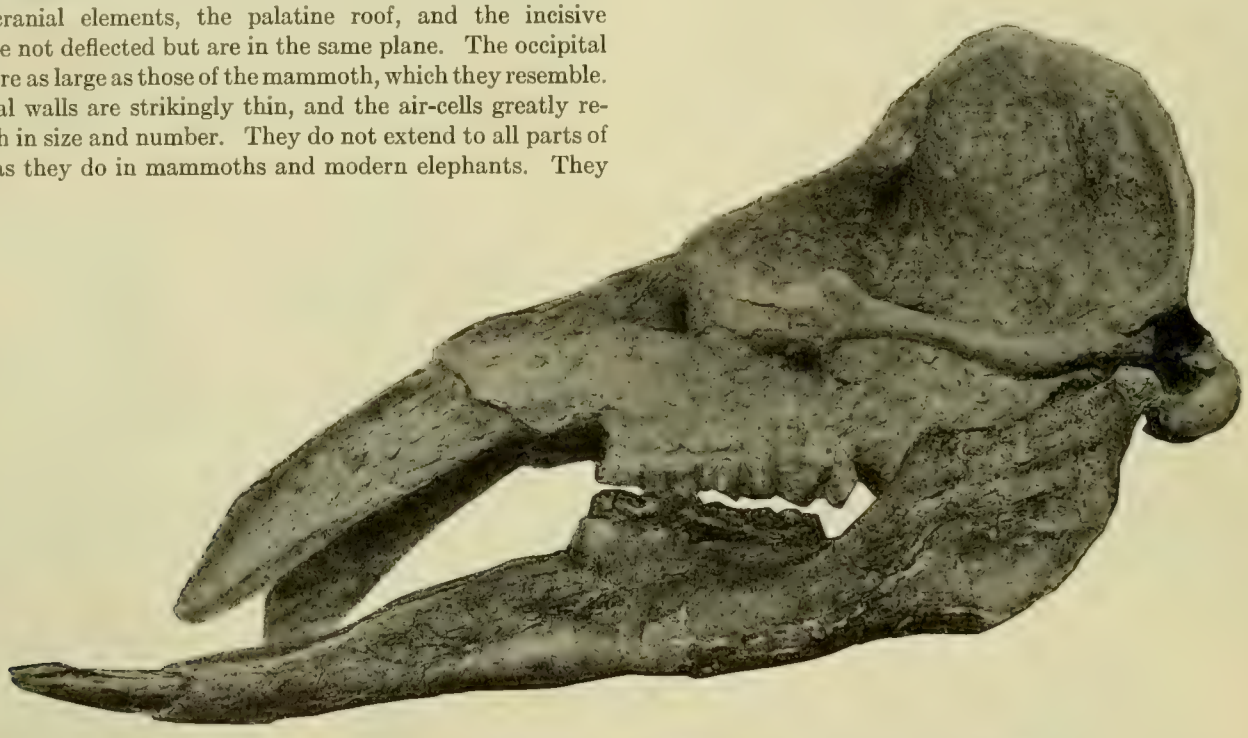
YOUNG ELEPHAS INDICUS (LEFT) AND ADULT TRILOPHODON OSBORNI (RIGHT)

Fig. 255. "Fore limbs, front view: a, Elephas indicus; b, Tetrabelodon osborni. Five ungual phalanges and metacarpals two and three, missing. Sections on either side for comparison. ×1/16." After Barbour, 1917, p. 510, fig. 11.

together with additional figures and restorations of which he has kindly sent us clichés.

Skull.—(1917, p. 508): "Since the above was written, the plaster 'cinches' have been removed from the palatine and occipital regions, and from most of the left side of the skull, well to its dome. In brief, the skull is that of an unelephant-like elephant. Barring innumerable cracks, the skull seems anatomically perfect, and is rich in morphological suggestions. It seems impressively simple and lacks the specialization of the later forms. The dome is unexpectedly low; the occiput flat, though rounding above; the pit small. All sutures are obliterated save those bounding the malar. The basicranial elements, the palatine roof, and the incisive sheaths are not deflected but are in the same plane. The occipital condyles are as large as those of the mammoth, which they resemble. The cranial walls are strikingly thin, and the air-cells greatly reduced both in size and number. They do not extend to all parts of the skull as they do in mammoths and modern elephants. They are wanting altogether in all portions of the zygomatic arch. The malar portion of the zygoma is relatively slender and weak; the maxillary portion heavy and strong; the postnarial aperture is disproportionately small. The temporal or squamosal process is very broad, heavy and strong, the condylar portion predominating. It exceeds that of the mammoth itself. The condylar articulation is upon the anterior border. The post glenoid portion is a thin, sharp ridge pendant from the flattened occiput. The glenoid fossa is located at the base of the post glenoid ridge and runs into the external auditory meatus, which is located close upon the basi-occipital. It is interesting to note the progressive migration of the meatus from a central position in our early proboscideans to one at the circumference in modern forms, and to observe the gradual arching over and union of the squamosal ridge and the post glenoid, as in the Indian elephant."

"The infraorbital foramen is encased in a sheath twice as long as that of E. columbi. The incisive sheaths are very short. The tusks though short are impressive because of their size and shape. They are 4 inches in diameter but expand noticeably toward the middle of the tusks and then contract to the pointed tips. On the under side they are produced to a blunt ridge, so a section is an acute, inverted ovoid. The enamel band is uncommonly broad, 2½ inches. In the Nebraska tetrabelodons the maxillo-premaxillary suture seems to run in a nearly straight line paralleling the axis of the tusk and does not curve under as in E. indicus."



Type Skull and Mandible of Trilophodon (Genomastodon) osborni. 'Prod-tusker'

Fig. 256. "Skull and mandible of the Boyd County Mastodon, Tetrabelodon osborni, showing protruding recurved jaw, low dome, slender zygomatic arch, short xiphoid tusks. Specimen perfect, barring frost cracks. × 1/9. Palæontological collections of Charles H. Morrill and Hector Maiben, The Nebraska State Museum." After Barbour, 1917, p. 500, fig. 1.

Trilophodon giganteus Osborn, 1921

Figures 171, 188, 257–259, 282

Lower Pliocene, Eastview, near Dallas, Gregory County, South Dakota. The life zone of *Trilophodon giganteus* is apparently equivalent to the Snake Creek B horizon of western Nebraska (see Chap. X) and slightly more recent, if anything, than the Republican River horizon.

This giant Longirostrine represents a singular combination of characters. The jaw is of hyperlongirostral type, the lower incisors are somewhat upturned so that they partly face each other, the upper incisors bear an enamel band on the inferior face of the tusk so that the enamel is abraded by the outer face of the lower incisors. The last upper and lower pairs of grinding teeth, namely, M^2-M_2, M^3-M_3, function at the same time; the third superior and inferior molars, M^3-M_3, are in the same stage of crest development as in *T. angustidens*, namely, $\frac{4}{4\ 1/2\text{-}5}$, that is, tetra-

TYPE SKELETON OF TRILOPHODON GIGANTEUS. 'OBLIQUE-TUSKER'

Fig. 257. Type skeleton of *Trilophodon giganteus* Osborn, 1921 (Amer. Mus. 17359). After photograph by Mrs. Elizabeth Rungius Fulda, retouched by Mrs. Lindsey Morris Sterling. One twenty-fourth natural size. See key to skeleton (Fig. 372). This is an 'oblique-tusker.'

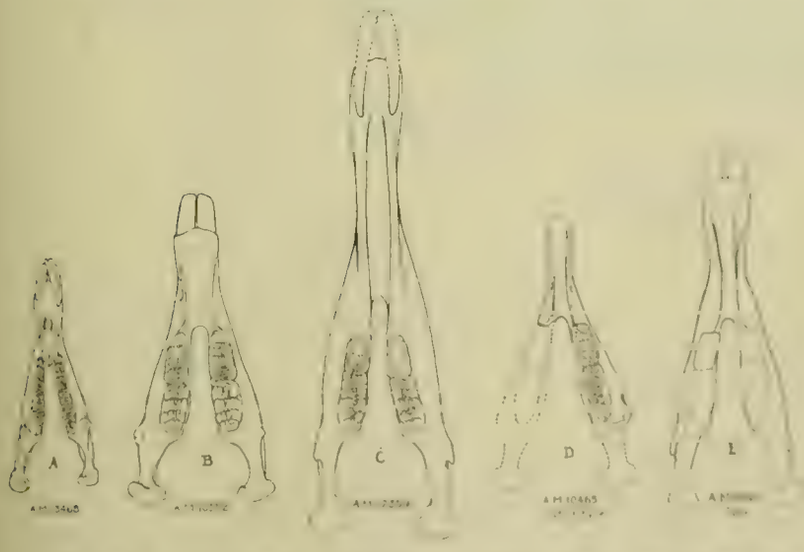


Fig. 258. C, Type figure of *Trilophodon giganteus* Osborn, 1921 (Amer. Mus. 17359), as compared with the lower jaws and grinding teeth of *Phiomia* and of the medilongirostrines *Serridentinus* and *Tetralophodon*. After Osborn, 1921.515, p. 9, fig. 4.

A, Type of *Phiomia osborni* Matsumoto (Amer. Mus. 13468). B, Referred *Serridentinus productus* (Amer. Mus. 10582). C, Type of *Trilophodon giganteus* Osborn (Amer. Mus. 17359). D, Type of *Tetralophodon longirostris* (drawn after cast of type, Amer. Mus. 10465, Warren Collection). E, Type of *Tetralophodon campester* Cope (Amer. Mus. 8527). All figures one twenty-fourth natural size. Grinding teeth in C, *Trilophodon giganteus*, foreshortened in drawing.

lophodont above, pentalophodont below; the pentalophid (Fig. 259 B2) is complete but much smaller than the tetartolophid. This stage of loph evolution as compared with that of the more progressive *Tetralophodon campester* and the less progressive *Serridentinus progressus*, *S. productus*, *S. serridens*, and *Phiomia osborni*, is shown in the accompanying diagram (Fig. 171). The relative elongation of the mandible as compared with that of the same species is shown in the type figure of *T. giganteus* reproduced herewith (Fig. 258). This figure shows that it is hyperlongirostral as compared with the medilongirostral species *S. productus*, *Tetralophodon campester*, and the *T. longirostris* of Kaup. This animal is of undoubted early Pliocene age, as shown in the following report by its discoverer Doctor Troxell.

GEOLOGIC AGE.—This remarkable skeleton was found by Edward L. Troxell in the summer of 1916 in the vicinity of Eastview, near Dallas, South Dakota, about two miles from the Nebraska line. (Troxell, letter, January 14, 1921) Whereas on the lower slopes of the Keyapaha there occur true Miocene beds, near the tops of the hills along the river Keyapaha, the upper zone on the north side of the river (near Dallas) corresponds to the Pliocene quarry near Springview, and to the beds near by in which was found the type of *Peraceras troxelli*. This whole formation seems to be as recent as the Oak Creek beds in which was found the type of *Pliohippus lullianus;* and all indicate an *early Pliocene age*. Matthew (letter, 1921) concurs entirely with Troxell: "I do not see that there is any

reasonable doubt about the Lower Pliocene age of the Troxell mastodon." The mammal fauna of the Oak Creek and Springview localities includes progressive *Hipparion;* among the true horses occur advanced forms of *Protohippus placidus* as well as *Pliohippus lullianus.*

The original type description by Osborn is as follows:

Trilophodon giganteus Osborn, 1921. "The Evolution, Phylogeny, and Classification of the Proboscidea." Amer. Mus. Novitates, No. 1, January 31, 1921, pp. 6–10. TYPE.—Skeleton and jaws (Amer. Mus. 17359). HORIZON AND LOCALITY.—Eastview, near Dallas, Gregory County, South Dakota; Lower Pliocene. TYPE FIGURE.—*Op. cit.*, 1921.515, p. 9, fig. 4C (Fig. 258 of the present Memoir).

TYPE DESCRIPTION.—(Osborn, *op. cit.*, 1921.515, pp. 8–10): "A new specific stage more recent in character than *T. [Ocal.] floridanus* Leidy appears to be represented in the skeleton and jaws (Amer.

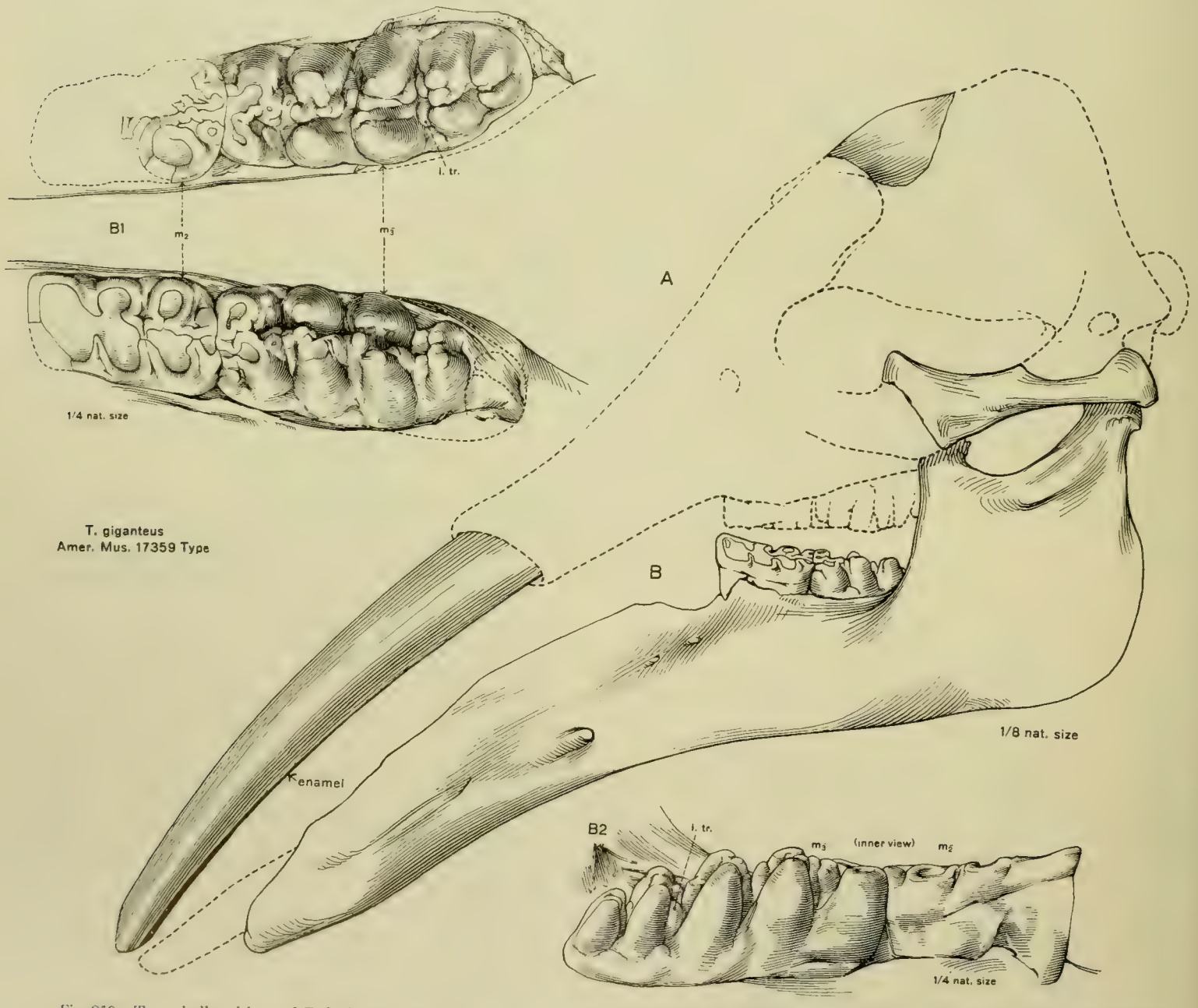


Fig. 259. Type skull and jaws of *Trilophodon giganteus* (Amer. Mus. 17359), found near Dallas, South Dakota, by E. L. Troxell; same individual as the reconstructed skeleton shown in figure 372. A, Left lateral view of largely restored skull, perfect left superior tusk; B, lower jaw without tusks. One-eighth natural size. B1, Crown view of lower molars, M_2, M_3. B2, Internal view of M_2, M_3 of the left side. One-fourth natural size.

Observe the edge of the enamel band on the inferior side of the tusk; also the well-developed external trefoils and single rudimentary internal trefoil (i. tr.) of M_3, a very significant *Trilophodon* character. The lower tusks are obliquely placed; compare *Trilophodon dinotherioides* (Fig. 236, p. 291).

Mus. No. 17359) discovered in South Dakota by E. L. Troxell in 1916, to which the name *Trilophodon giganteus*, new species, may be applied. It exhibits rudiments of double trefoils and the lower incisors are upturned at the sides so as to face partly inward (Fig. 4C). . . . In *T. giganteus* . . . the two lower tusks turn toward each other. A characteristic, of all the Miocene grinders observed, is the presence of a single trefoil invariably appearing first on the inner side of the upper teeth and on the outer side of the lower teeth. . . . In all Pliocene species observed the intermediate molars are four-crested; hence they fall within the genus *Tetralophodon* Warren, Falconer [*Tetralophodon* Falconer, 1847, Warren, 1852]. From the Middle Miocene apparently to the close of the Middle Pliocene there was a steady addition of crests to m_3^3, rising from four and a half crests in the Middle Miocene (*T. angustidens*) to seven and a half [8⅓] crests in the Middle Pliocene[1] (*T. barbouri*, new species). At the same time the crests become subhypsodont partly coated with cement."

Osborn, 1923: This animal appears to represent a large and very massive stage in the evolution of the *Trilophodon angustidens* phylum; the skeleton is even more massive than that of the true *Mastodon americanus*, hence the specific name *giganteus* was given to it. The dental proportions are as follows:

M_2			M_3			M_{2-3}
ap.	tr.	I.	ap.	tr.	I.	
140e	86	61e	172	91	53	305e

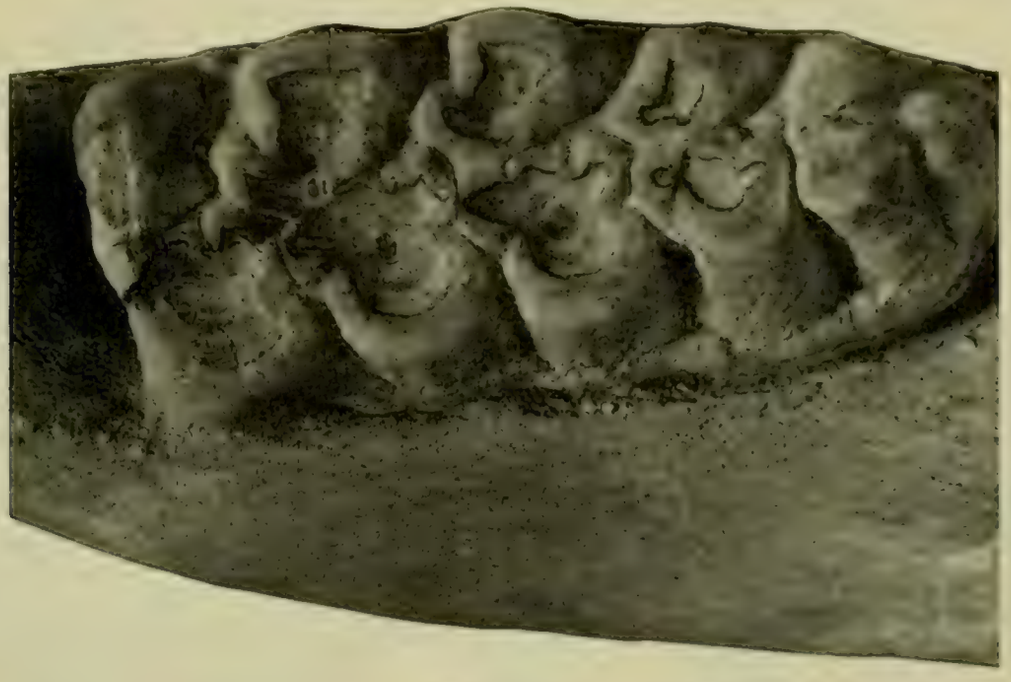
These measurements and indices should be compared with those of *Amebelodon* (*Trilophodon*) *hicksi* Cook below.

Amebelodon (Trilophodon) hicksi Cook, 1922

Figures 188, 260–262

Middle Pliocene (?), Wray, Yuma County, Colorado.

The discovery of the type of *Amebelodon* (*Trilophodon*) *hicksi* (now in the Colorado Museum of Natural History) and the measurements and description of this specimen by Harold Cook in 1922 constitute a very important addition to our knowledge of the *Amebelodon* phylum. The geologic age of the quarry at Wray, Yuma County, Colorado, is possibly Middle Pliocene, the beds including both *Teleoceras* and *Aphelops* as described below. The fact that the two last lower molar teeth, M^2-M_2, M^3-M_3, are functional in the young condition indicates that this animal is of a less progressive stage than the genotypic species *Amebelodon fricki* of Barbour. This species is clearly distinguished by the last lower molar which has five strong crests and a rudimentary sixth crest, as against four and a half crests in *Trilophodon giganteus* of Osborn. While the jaw is long and slender, it does not resemble the hyperlongirostral type of *T.* (*Megabelodon*) *lulli*. The index of the third lower molar is as follows: ap. 199 mm., tr. 80 mm., I. 40.



Type Molar of Amebelodon (Trilophodon) hicksi. A 'Shovel-tusker'

Fig. 260. Type figure of type lower molar, left side, l.M_3, of *Trilophodon hicksi* Cook. Colo. Mus. Nat. Hist. No. 310. Crown view. Two-thirds natural size. After Cook, 1922, p. 11, fig. 2.

The elongated and flattened incisive tusks (Fig. 261) resemble those of *Amebelodon* (*Trilophodon*) *paladentatus* (Fig. 263).

Geologic Level and Fauna.—The finely preserved type jaw of *Amebelodon* (*Trilophodon*) *hicksi* (Colo. Mus. Nat. Hist. 310—Fig. 261) is reported by the author as follows (1922.1, pp. 2, 3): "An expedition in charge of Mr. Philip Reinheimer, under the supervision of Director J. D. Figgins, went in the summers of 1918–1919 to the ranch of Mr. H. D. Boyes, near Wray, Yuma

[1] *Tetralophodon* (*Morrillia*) *barbouri* is now (1935) regarded as of Middle Pleistocene age.

County, Colorado, where Mr. Boyes had reported finding a rich deposit of fossil bones. . . . These fossil remains were all found lying directly on top of and in contact with the Pierre Shale, in a thin wash deposit a few feet thick, that is evidently of late Miocene or early Pliocene origin, and probably represents a stream deposit of that age. Considering the number of specimens found, a surprising variety is represented. All were found in an area of about 20 by 75 feet. . . . . Associated with these elephants is a very interesting fauna, which the writer so far has only had the time to glance over. It includes several horses in the three-toed stage, the short-legged rhinoceros *Teleoceras*, a large species of *Aphelops*, large dogs, cats, peccaries, cervids, camels, and other forms not yet determined. This assemblage at first glance appears to approximate Lower Pliocene age."

same individual, was a skull, which curiosity hunters had all but destroyed, and from which a complete last upper molar [Fig. 262] and some upper tusk parts were recovered. There can be little doubt that this upper molar belongs to the same species, even though it might not be the same individual as the type specimen, as the tooth corresponds very closely with the corresponding lower molars. Other skeletal material also found with this probably belongs to this type specimen, but as other individuals and species of elephants, as well as other kinds of animals, were also found mixed up in the same small area, it is well to be slow about associating parts not positively known to belong together."

"This species has two functional lower molars, but unfortunately the intermediate molar, or molar five, in each jaw, had been lost out, so that we cannot be sure what number of crests it possessed;

TYPE OF AMEBELODON (TRILOPHODON) HICKSI. 'SHOVEL-TUSKER'

Fig. 261. Type figure of type specimen of *Trilophodon hicksi* Cook. Colo. Mus. Nat. Hist. 310. Lower jaws, crown and side views. One-eighth natural size. After Cook, 1922, p. 10, fig. 1. The extremely elongated and flattened lower tusks indicate that this stage is ancestral to *Amebelodon fricki* (Figs. 287, 290). This is a 'shovel-tusker.'

Trilophodon hicksi Cook. "Two New Bunomastodonts from Colorado." Proc. Colo. Mus. Nat. Hist., Vol. IV, No. 1, February 15, 1922, pp. 5 and 6. TYPE.—Pair of lower jaws, with last lower molars on each side and lower tusks. Original in the Colorado Museum of Natural History (No. 310). HORIZON AND LOCALITY.—Found on the ranch of Mr. H. D. Boyes, near Wray, Yuma County, Colorado; Middle Pliocene(?). TYPE FIGURE.—*Op. cit.*, p. 9, figs. 2 and 3, p. 10, fig. 1, p. 11, fig. 2.

TYPE DESCRIPTION.—(*Op. cit.*, pp. 5 and 6): "*Trilophodon hicksi*, sp. nov. The type specimen of this species is a splendidly preserved pair of lower jaws, in the Colorado Museum of Natural History, Colo. Mus. No. 310, and is free from crushing and distortion, but was damaged by vandals after being exposed while being collected in the field. The lower tusks and the last lower molars on each side are present and in fine condition, and the animal was fully mature in age. Associated with this, and probably belonging to the

but it was small and two-rooted, and its size suggests the three-crested or *Trilophodont* type. The last molars have crests with double trefoils, and have five strongly developed crests, and a sixth crest forming. The same condition prevails in the upper referred molar, but the sixth crest is better developed, and the fifth relatively larger than in the lower molars."

"The striking feature of this specimen is the strong, heavy, flattened lower tusks, which are long and parallel, about $\frac{5}{8}$ of an inch apart, turning up at the outside edges, so that they are actually concave; and together form a tool that reminds one of a spoon, or posthole spade. This is carried to a still greater degree in the second species described herewith, and suggested its name. These lower tusks run back to where the lower jaws divide at the symphysis. The symphyseal prolongation of the jaw is heavy and strong, and turns downward in a manner which suggests *Rhynchotherium* affinities. No enamel band is present on the lower tusks. They

show heavy wear, and were probably used in digging out roots, or tearing out plants wanted for food. The asymmetrical wear they present is probably due to some individual habit of the animal, by which he twisted and used his jaws one way harder than the other, when grubbing with them. The upper tusks which presumably belong to that form also show evidence of hard use. The angle of the jaw is very low and rounded, more like that seen in *Eubelodon morrilli*, Barbour [Barbour, 1914.1]. The ascending ramus is fairly high and strong, with a strongly developed coronoid, but unfortunately both coronoid and condyles were damaged in the quarry by vandals, before the specimen could be secured."

"While the total length of the jaws and tusks is not as great as in some other described species, the lower tusks are much larger and stronger, and the symphyseal prolongation is proportionally stronger and more massive, than in such forms as *T. lulli* and *T. osborni* [Barbour, 1914.3, 1916]. In the species recently described by Osborn as *T. giganteus* [Osborn, 1921.515], the lower incisors are upturned at the sides in a way suggestive of this and the accompanying species. In addition to the usual large mental foramen, there are two other large foramina posterior to this on the outside of the jaw along the symphysis, and a fourth fairly large foramen above and between these, up near the alveolar border. This ridge is rather high and sharp, on each side of the deep lingual groove. The last lower molar of this species has five strong crests and a rudimentary sixth, as against four strong crests and one fairly well developed in *T. giganteus;* and also in *T. osborni*, which points to an advancement over these species."

Osborn, 1927: This animal appears to represent a large and progressive species in the presence of double trefoils on the fourth ridge-crest of the inferior molars and in the progressive ridge-crest formula, namely, M3 $\frac{}{5\ 1/2}$; the measurements of M_3 (ap. 199 mm., tr. 80 mm., index 40) greatly exceed those of *Trilophodon giganteus* above.

Amebelodon (Trilophodon) paladentatus Cook, 1922

Figures 188, 263-235

Middle Pliocene, Wray, Yuma County, Colorado.

The type of this animal, a lower jaw, was found in the same locality as the type of *Amebelodon (Trilophodon) hicksi* described above by the same author, namely, at Wray, Yuma County, Colorado. The type belongs to a very aged animal, the third inferior molar tooth (Fig. 264) being much worn. It is apparently four and a half crested or tetralophodont as in the *T. angustidens* stage. As described by the author below: "The [fractured] molar has four crests, and is wide anteriorly, tapering posteriorly, and in the present stage of extreme wear, the fourth or last crest looks more like a talonid, or heel, than a Proboscidean crest."

Fig. 262. Referred figure of associated right last upper molar of *Amebelodon (Trilophodon) hicksi* Cook, presumably same individual as type. Colo. Mus. Nat. Hist. 329. Four-fifths natural size. After Cook, 1922, p. 12, fig. 3. A 'shovel-tusker.'

The tusks or the preserved lower incisor teeth (Fig. 263) are twisted on their axes, the anterior extremities being horizontal, the posterior being vertical. A large portion of the bone of the ramus has been destroyed, consequently the hyperlongirostral character of this type specimen is concealed. We attribute to the advanced age of this animal the fact that only one pair of molars, M^3-M_3, is in use.

Osborn, October, 1933: The type ramus and incisive tusk of *Trilophodon paladentatus* (Fig. 263) apparently represent an ancestral stage of the type of *Amebelodon fricki* (Fig. 291); therefore *T. paladentatus* is now transferred to the Amebelodontinæ.

TYPE OF AMEBELODON (TRILOPHODON) PALADENTATUS. A 'SHOVEL-TUSKER'

Fig. 263. Type figure of type specimen of *Trilophodon paladentatus* Cook, Colo. Mus. Nat. Hist. 311. Lower jaws, crown and side views. One-eighth natural size. After Cook, 1922, p. 13, fig. 5. Compare these incisive tusks with those of the shovel-tusker *Amebelodon fricki* (Fig. 291). This stage appears to be ancestral to *Amebelodon fricki* (Fig. 287).

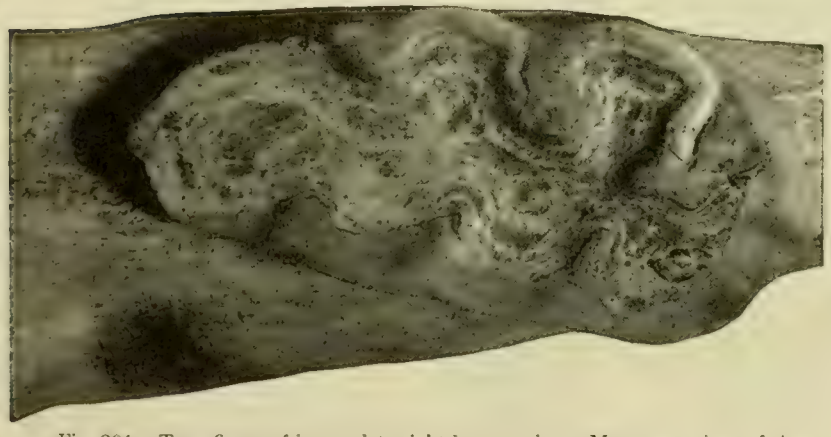


Fig. 264. Type figure of incomplete right lower molar, r.M_3, crown view, of *Amebelodon* (*Trilophodon*) *paladentatus* Cook, Colo. Mus. Nat. Hist. 311. Two-thirds natural size. After Cook, 1922, p. 14, fig. 6. Measurements: ap. 174 mm., tr. 79 mm., index 45.

Fig. 265. Parts of two upper tusks found with the types of *A.* (*T.*) *hicksi* and *A.* (*T.*) *paladentatus*, showing enamel bands on external concave surface. Association uncertain. Colo. Mus. Nat. Hist. 315 and 314. One-sixth natural size. After Cook, 1922, p. 14, fig. 4

Trilophodon paladentatus Cook. "Two New Bunomastodonts from Colorado." Proc. Colo. Mus. Nat. Hist., Vol. IV, No. 1, Feb. 15, 1922, pp. 6 and 7. TYPE.—Pair of lower jaws. Original in Colorado Museum of Natural History (No. 311). HORIZON AND LOCALITY.—Found on the ranch of Mr. H. D. Boyes, near Wray, Yuma County, Colorado; Middle Pliocene. TYPE FIGURE.—*Op. cit.*, p. 9, fig. 1, p. 13, fig. 5, p. 14, fig. 6.

TYPE DESCRIPTION.—(Cook, 1922, p. 6): "*Trilophodon paladentatus*, sp. nov. The type of this species is a pair of lower jaws, complete when found, but partly destroyed by vandals before it could be removed from the quarry. The specimen is No. 311, Colorado Museum of Natural History, and at present is fairly complete, except for one molar, one tusk, and most of the symphyseal prolongation of the jaws. However, as the bone impression is plainly visible on the lower tusk, the actual length of the jaw bones can be quite accurately measured."

"There is a striking similarity between the type of lower tusks in this form and *T. hicksi*, but the tusk is not only larger, but even more flattened and concave in this species, which suggests its specific name. The jaw apparently turned down rather sharply, as in the Rhynchorostrinæ, but no enamel band is present, and the molars are reduced to one on each side. This is a very simple tooth, and while worn down with age, apparently had trefoil crests. The molar has four crests, and is wide anteriorly, tapering posteriorly, and in the present stage of extreme wear, the fourth or last crest looks more like a talonid, or heel, than a Proboscidean crest. The triturating surface of the tooth has a sharp backward slant, such as is found in *T. osborni*, but much more pronounced, and in fact more pronounced than in any species which we have seen. The molars most closely parallel the condition found in *T. lulli* of any described species, but differ from that species in proportions, and angle of wear, to a marked degree; and the tooth is not only proportionally but actually much smaller, being approximately seven inches long, as against nine inches in *T. lulli*. There is no evi-

dence of there having been other functional molars present in this form. The mandible without the tusk is somewhat shorter than in *T. hicksi*, but the tusk being larger and longer, makes the jaw and tusk together slightly longer (2½ inches) in *T. paladentatus*."

"The angle of the jaw is heavier and more acute, than in *T. hicksi*, and the coronoid relatively high and strong. Correlated with the reduced dentition, the rami in the vicinity of the molars are less massive, but are deep and well braced to support the heavy lower tusks. The tusks make a full quarter turn in their length, standing edgeways at the base of the tusks inside the jaw, the upper edge twisting gradually on a long curve outward until they lie flat at the tips, which accentuates the spoon-like appearance. They evidently had heavy use. The jaws are relatively narrow across the condyles, indicating a narrow skull."

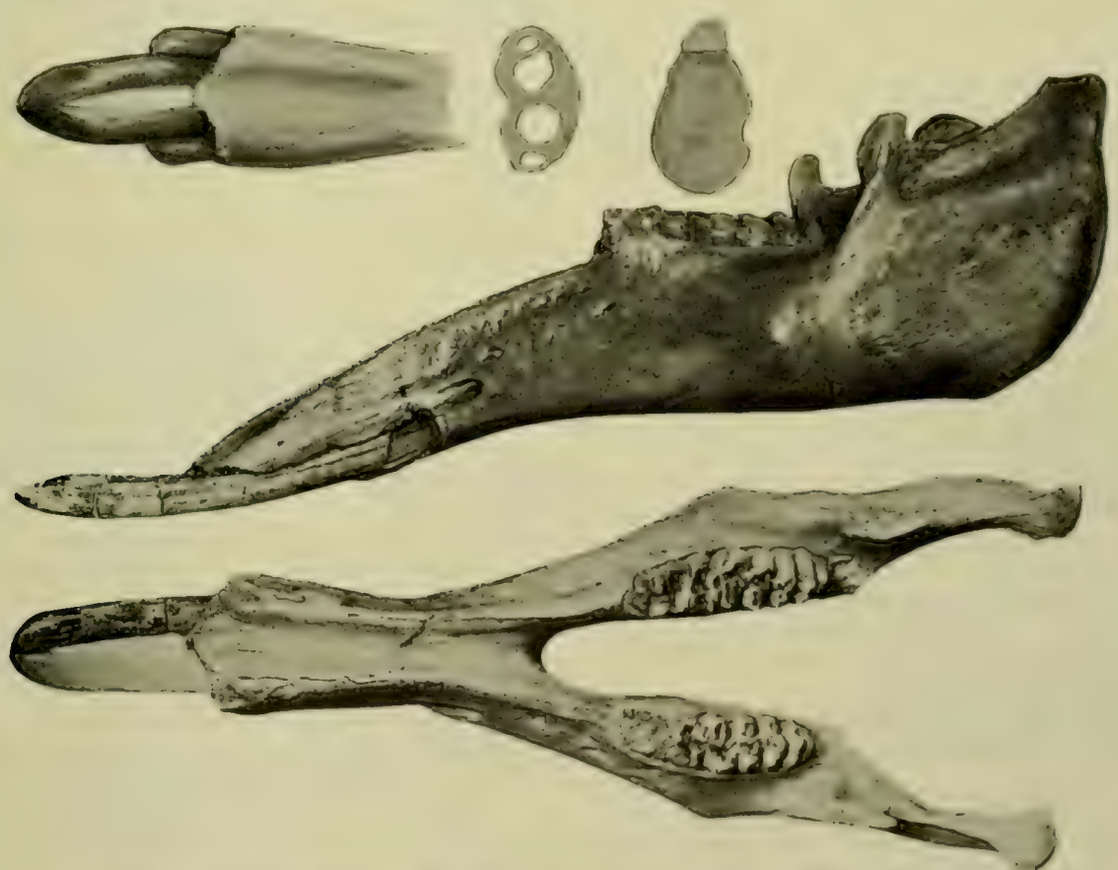
"Unless individual variations existed in tooth structure and other details beyond anything which experience has led us to believe, then these two species described herewith, in spite of close similarity in some details, must really be a good distance apart phylogenetically. If Osborn is correct in separating the Proboscidea into at least a dozen distinct phyla (and his work is always recognized as being in the first rank) then it is not surprising to find such parallelism, and it is doubtful if these species can belong in the same genus. But as the Proboscidea are now undergoing a careful world-wide study by able men, it seems best to record them in this manner, and as the phyla become better known, proper generic reference can be made."

Trilophodon abeli Barbour, 1925

Figures 188, 266

Lower Pliocene. Devil's Gulch, Brown County, Nebraska

Dentition practically perfect, of the typical *Trilophodon* type. Adult lower incisive tusks, I_2, with regular sockets; also side sockets 10 inches long, ¾ inch in diameter, two vestigial lateral incisors ([?Di_2], Figs. 54, 55—Fig. 266 of the present Memoir); mandible finely preserved, flaring at the extremity, angle large, condyle and coronoid more elevated than in *Trilophodon* (*Genomastodon*) *osborni* or in *Eubelodon morrilli;* mental foramen less elongated; depression under each grinder on either surface of ramus, 6×2 inches; protuberance on outer border below interval between M_2 and M_3.



Type of Trilophodon abeli. Abnormal Duplication of Incisive Tusks. A 'Prod-tusker'

Fig. 266. Type mandible of *Tetrabelodon abeli* Barbour, 1925.2, figs. 52-56, pp. 92 and 93 (Neb. Mus. 1-12-9-24S). All figures one-ninth natural size.

(Lower) "Fig. 53.—Mandible. . . . Crown view."

(Middle) "Fig. 52.—Mandible. . . . Right side reversed to face left. The circular highlight under the last molar is a strong protuberance, better shown in Fig. 53."

(Upper—left) "Fig. 54.—Tip of mandible . . . , with lateral tusks supplied."

(Upper—center) "Fig. 55.—Section across the tip of the mandible, showing two central sockets and two lateral sockets."

(Upper—right) "Fig. 56.—A section of the mandible in Fig. 52, through the last molar."

Tetrabelodon abeli Barbour, 1925. "Tetrabelodon abeli Sp. Nov." Neb. State Mus., Bull. 9, I, August, pp. 91–94 (Barbour, 1925.2). TYPE.—Mandible containing the second and third molars of each side (Neb. Mus. 1–12–9–24S). TYPE LOCALITY AND HORIZON.—(*Op. cit.*, p. 94): "This mandible was found in Devil's Gulch, Brown County, Nebraska, by Mrs. J. F. Francis, by whom it was carefully dug out and preserved. Later it was procured for the palaeontological collections of Mr. Hector Maiben by William Strong, while doing field work during the summer of 1924." Lower Pliocene. TYPE FIGURE.—*Op. cit.*, text figs.52–56.

"MANDIBLE	mm.	inches
Length, tip of symphysis to back of condyle	1156	45½
Tip of tusk to back of condyle	1359	53½
Depth of jaw at molar	190	7½
Thickness of jaw at molar	165	6½
Length of symphysis	470	18½
Width of tip	184	7¼
Across condyle	489	19¼
TUSK		
Exposed portion of tusk	216	8½
Total length of tusk	508	20
Diameter of tusk	51	2
MOLARS		
Length of the two molars	292	11½
Length of last molar	185	7¼
Greatest width of last molar	76	3"

Osborn, 1933: This beautifully preserved type jaw (Fig. 266) appears to present an anomaly either in the retention of the inferior milk incisors, Di_2, or in the reduplication of the permanent incisors, I_2. The measurements of the last inferior molar, length 185 mm. × width 76 mm., exceed those of the type of *Trilophodon giganteus* (Amer. Mus. 17359), 172 mm.×91 mm., but are less than those in *T. ligoniferus* type (Amer. Mus. 8531), 245 mm.×92 mm.; the measurements approximate those of *Amebelodon* (*T.*) *hicksi* (199 mm.×80 mm.), as shown in the comparative table (p. 288); the closest resemblance in measurements of the grinders, however, is to the type of *T. osborni* Barbour, as described above (p. 298); in fact, the type jaw of *T. abeli* seems to be in a stage of progressive evolution somewhat similar to the type jaw of *T. osborni* (Fig. 247); the grinding teeth are clearly distinguishable from those of the type of *A.* (*T.*) *hicksi* by the absence of an additional crest (pentalophid) which distinguishes *A.* (*T.*) *hicksi* (Figs. 260 and 262).

Trilophodon fricki Peterson, 1928

Figures 267 and 268

Middle to Upper Miocene, Brown's Park formation, Weller horizon. Northern flanks of Douglas Mountain on the Weller Ranch, Moffat County, Colorado. [H.F.O., 1931: For fauna, see page 315 below. Nearly contemporaneous with *Serridentinus proavus* of Pawnee Creek B, and *Miomastodon merriami* ref. of Pawnee Creek.]

This most welcome Middle Miocene stage, with cranium and dentition fully known, is one of the most primitive Trilophodonts thus far discovered in North America. Compare *Trilophodon simplicidens* (Fig. 231, p. 285).

Serridentinus fricki Peterson, 1928. "The Brown's Park Formation." Mem. Carnegie Museum, Vol. XI, No. 2, April 8, 1928, pp. 111–121, Pls. IX-XV, text figs. 21, 22. TYPE.—"Greater portion of skull and lower jaws found interlocked in normal position; fragments of vertebræ; ribs and limb bones of an adult, but not old, individual, No. 11,379, C. M. Cat. Vert. Foss." HORIZON AND LOCALITY.—Brown's Park formation, Weller horizon, Middle Miocene. Northern flanks of Douglas Mountain on the Weller Ranch, Moffat County, Colorado. TYPE FIGURE.—Pls. XI–XIV, and text figs. 21 and 22. See also restoration by Dr. Andrey Avinoff (Pl. XV).

TYPE DESCRIPTION.—(Peterson, 1928, pp. 111–114): "Symphysis of lower jaws relatively long, closely approaching condition shown in '*Trilophodon*' *giganteum* [Footnote: 'Amer. Mus. Novitates, No. 1, Jan. 31, 1921, Fig. 4, c. Outline view of lower jaws of *T. giganteum.*']. Lower incisors rounded, slightly converging toward the apices as in '*Trilophodon*' *osborni* and somewhat suggesting the condition found in '*T.*' *giganteum*. . . . Upper tusks relatively long, laterally compressed, slender, with comparatively narrow and light enamel band. Occipital plate of skull well rounded from side to side. Second and third molars fully developed."

"*Serridentinus fricki* is provisionally placed between *Trilophodon* ('*Tetralophodon*') *osborni* Barbour . . . and *Trilophodon* (*Serridentinus*) *pojoaquensis* Frick, . . . perhaps closer to '*T.*' *osborni*. The species from Brown's Park is separated from *S. pojoaquensis* Frick by its longer and slenderer tusks, narrower and lighter enamel band, and the more anterior location of the infraorbital foramen. Furthermore, the paratype [1] of Frick's species (Skull No. 21,125 A. M. N. H.) has a shorter and higher cranium, the occipital plate almost square transversely, from side to side with very little forward rounding at the base of the zygomatic arches, while this region in our species is much more rounded."

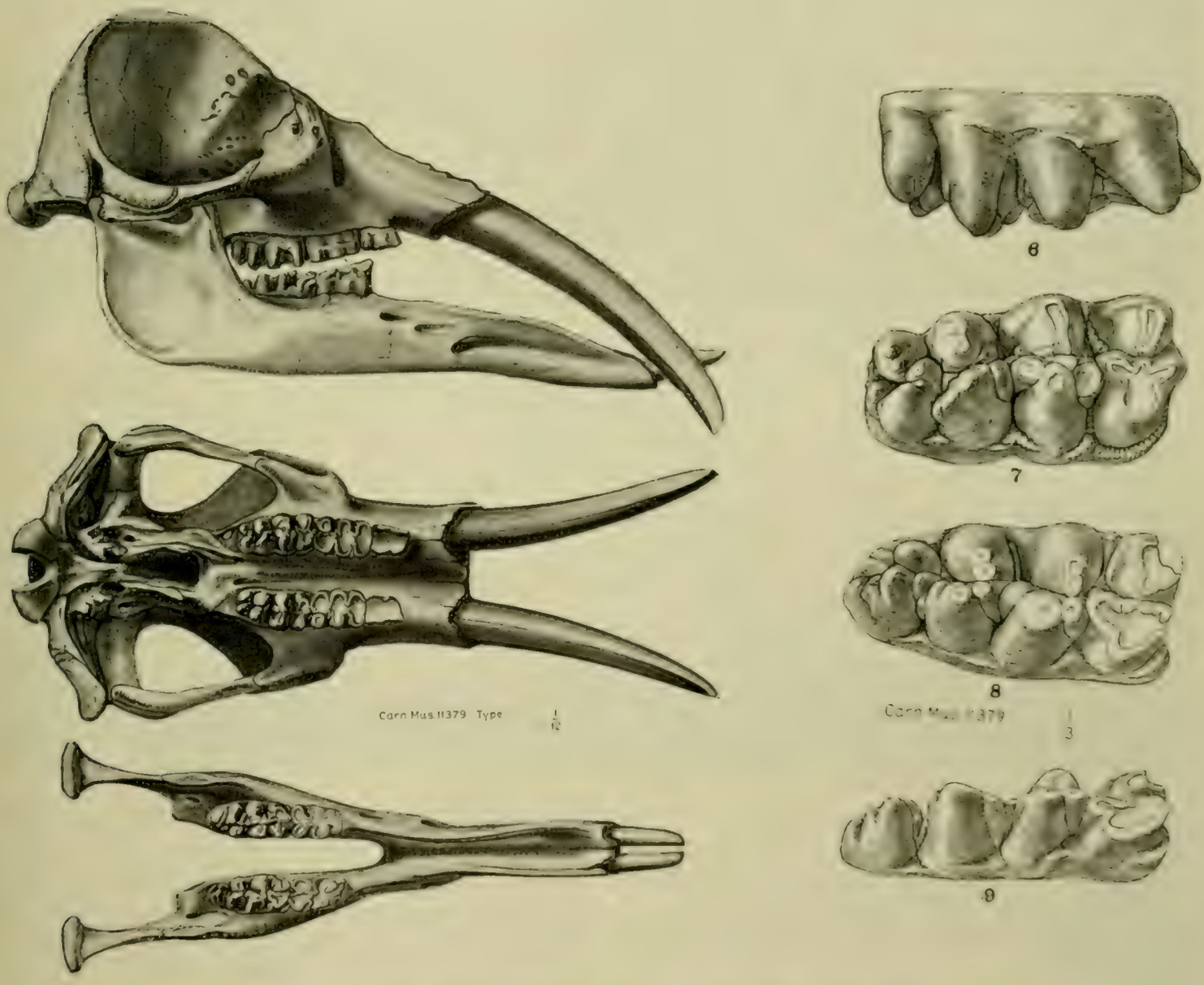
"In comparing the illustrations and measurements of the skull, which Professor Barbour associates with the lower jaws of '*Trilophodon*' *osborni* Barbour, the differences between '*T.*' *osborni* of Barbour and *S. fricki*, appear even greater. The total length of the skull of Barbour's type is actually less than that in our specimen, while the lower jaws are relatively longer and thicker as noted. The tusks of the Nebraskan species are short and heavy as in Frick's species *T. pojoaquensis*. On the other hand the tusks in the specimen from Western Colorado are long and rather slender. The relative measurements of the Coloradan and Nebraskan species are all rather discordant. If the skull and lower jaws of '*Trilophodon*' *osborni* Barbour are correctly associated, they bring to light a remarkable condition. The upper tusks, though well formed and strong, do not reach to the front of the symphysis of the lower jaws and apparently never did reach the anterior part of the incisors to protect them in any way, or assist in their function: in fact the illustration by Professor Barbour indicates the upper tusks to be of seemingly little or no use, as Barbour himself

[1](1934): The above specimen ("Skull No. 21,125 A.M.N.H." = Frick Coll., Amer. Mus. 21125) is now referred to *Ocalientinus ojocaliensis* Frick (see Chap. X, pp. 435–439).

states. This is truly a most curious anomaly not usually encountered in morphological studies."

"As has been stated, the skull and lower jaws of the specimen from the Brown's Park sediments were found perfectly articulated. In this species it is clear that the upper tusks touched the lower when the jaws were in motion and thus the tusks, upper and lower, functioned in a perfectly normal manner."

"The lower tusks are in general shape and proportion, quite similar to those in '*Trilophodon*' *osborni*, as described and illustrated by Professor Barbour. In the lower jaw there are only two molars on either side, which apparently agree in most details with those of '*T.*' *osborni*."



TYPE OF TRILOPHODON FRICKI PETERSON. 'PROD'- OR 'UPROOT-TUSKER' OF COLORADO

Fig. 267. Type cranium, mandible, and dentition of *Scrridentinus fricki* Peterson, 1928. After original drawings kindly sent by Mr. Peterson to the present author (cf. Peterson, 1928, Pls. XII, XIII, and XIV, figs. 6–9). Cranium and mandible one-twelfth natural size; superior (Figs. 6, 7) and inferior (Figs. 8, 9) molars one-third natural size. Compare *Trilophodon simplicidens* of Florida, Fig. 231, p. 285.

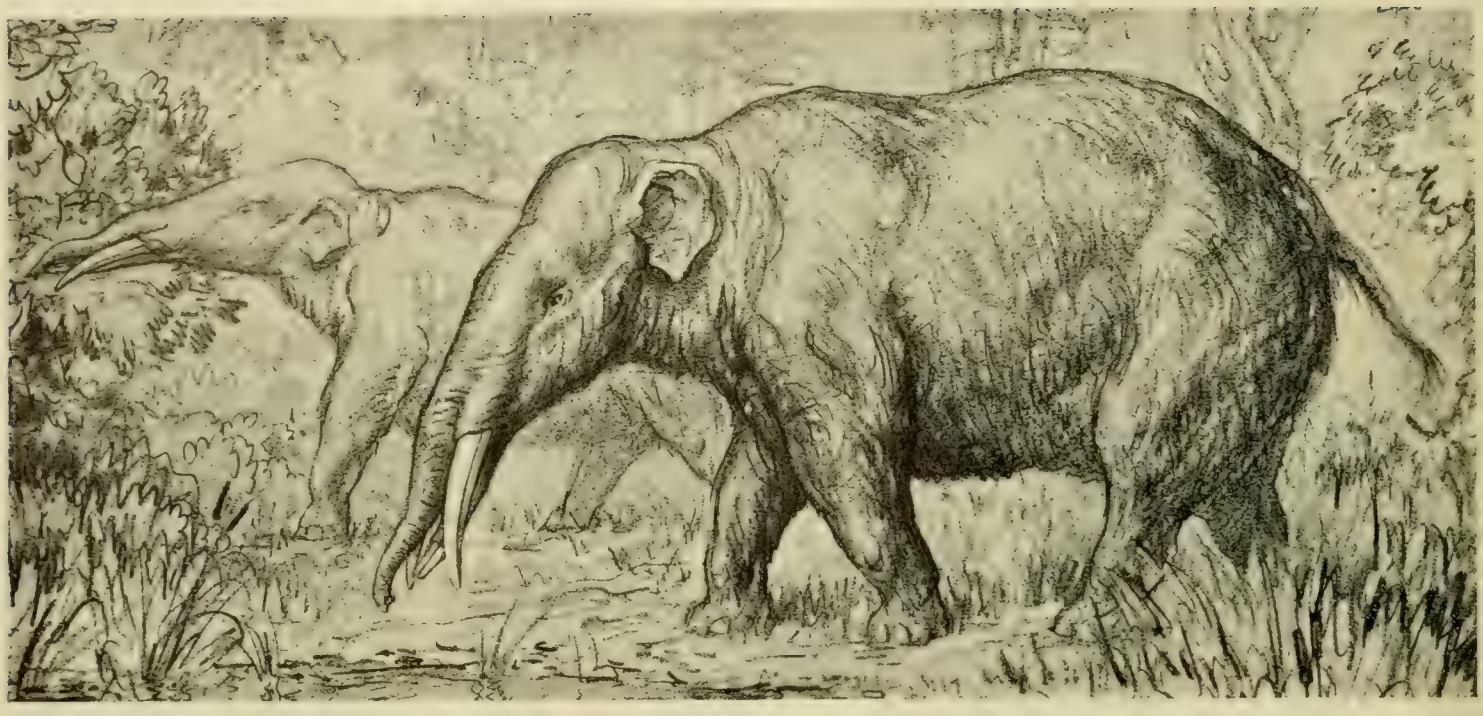


Fig. 268. Restoration of *Trilophodon* (*Serridentinus*) *fricki* Peterson, of the Middle Miocene of northwestern Colorado. After original pencil drawing by Dr. A. Avinoff, Director of the Carnegie Museum of Pittsburgh. Compare Peterson, 1928, Pl. xv.

MEASUREMENTS IN MILLIMETERS

	Trilophodon fricki	*Trilophodon osborni*
SKULL		
Occiput to tip of incisor	1555	1365e
Occiput to alveolar border of incisor	950[1]	
Occiput to infraorbital foramen	600	
Transverse diameter across zygomatic arch	680[1]	
SUPERIOR MOLARS		
Total anteroposterior diameter M^{1-3}	350	
Anteroposterior diameter of first cheek tooth, M^1	84	
Transverse diameter of first cheek tooth, M^1	64	
Anteroposterior diameter of second cheek tooth, M^2	117	
Transverse diameter of second cheek tooth, M^2	75	
Anteroposterior diameter of third cheek tooth, M^3	162	
Transverse diameter of third cheek tooth, M^3	82	
LOWER JAW		
Condyle to tip of inferior incisor	1292	1522[1525]
Condyle to posterior edge of symphysis	734	870e
Total anteroposterior diameter M_{2-3}	285	
Anteroposterior diameter of first cheek tooth, M_1	120	
Transverse diameter of first cheek tooth, M_1	70	
Anteroposterior diameter of third cheek tooth, M_3	172	190[196]
Transverse diameter of third cheek tooth, M_3	73	76 [80]

Osborn, 1928: The above quotations from Peterson's very full description and measurements (*op. cit.*, pp. 111–118), accompanied by his admirable figures (text figs. 21, 22, Pls. XI–XV, including an excellent restoration by Dr. Andrey Avinoff) constitute, together with the description and fauna of the Brown's Park formation, one of the most important recent palæontological contributions to the American Tertiary.

Trilophodon fricki (M_3, ap. 172 mm., tr. 73 mm.) is inferior in size to Barbour's type of *T. osborni* (M_3, ap. 196 mm., tr. 80 mm.); in *T. fricki* M_3 has 3¾–4 transverse crests and no heel, whereas in *T. osborni* M_3 has "four transverse crests and a large heel" (see Barbour, 1916, pp. 523–527). Consequently *T. fricki* is a much more primitive species than *T. osborni*. Its very primitive character is also revealed (Peterson, *op. cit.*, Pl. XII—Fig. 267 of the present Memoir) in the rounded occipital crests and temporal fossæ, characters partly due to the juvenile condition of this type individual of *T. fricki* and to the retention of three superior grinding teeth, M^{1-3}, *in situ*. Its reference to *Trilophodon* rather than to *Serridentinus* is justified by an examination of the crown and side

[1] "Indicates measurements in part estimated."

views of the superior and inferior molars, in which the central conules appear in the very center of the crown, as in the type of *T. angustidens* Cuv.

Fauna. The associated fauna of *Phlaocyon*, *Bassariscops*, *Ticholeptus*, *Merycodus*, *Aphelops ceratorhinus*, the chalicotheroid *Moropus*, the cameloids *Oxydactylus* ref. and *Stenomylus* ref. are in accord with the very primitive character of this superbly preserved proboscidean skull and dentition and render probable the late Miocene (=Tortonian) age of *Trilophodon fricki* (see pp. 88, 96, and 121 of Peterson's Memoir), equivalent either to Pawnee Creek A, Colorado (*Merychippus sejunctus* zone), or to the Bristow beds, Nebraska, of Barbour (*Trilophodon osborni* level).

Trilophodon phippsi Cook, 1928

Figures 269–271

From near Ainsworth, Brown County, Nebraska. Correlated provisionally by Cook with the Devil's Gulch B beds of Barbour. Lower Pliocene.

This northern Nebraska bunomastodont is a typical *Trilophodon*, much more progressive than *Trilophodon fricki* Peterson of the Middle Miocene, Weller horizon, of Moffat County, Colorado. In the type cranium and mandible (Figs. 269, 270), the most distinctive character is the entire absence of the inferior incisive tusks, regarded by Cook, the describer, as a constant specific character.

In the referred cranium (Fig. 271) of *Trilophodon phippsi* (Amer. Mus. 22411—Frick Coll.) the mandible is imperfectly

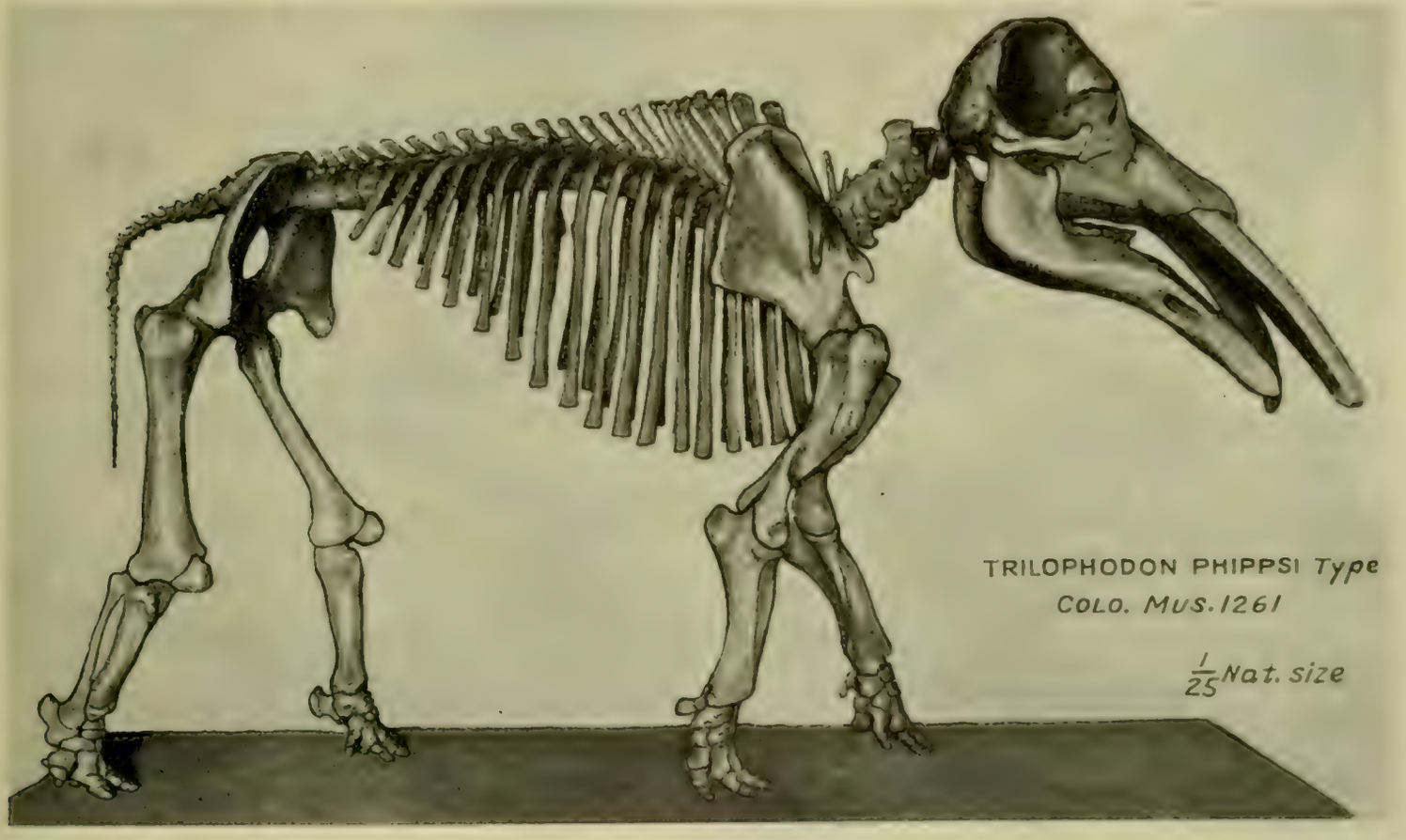


Fig. 269. *Trilophodon phippsi* Cook, type mounted skeleton in the Colorado Museum of Natural History (Colo. Mus. 1261), discovered in the year 1927 near Ainsworth, Brown County, Nebraska, in the local exposures of the Devil's Gulch beds, northwest Nebraska. After photograph kindly forwarded to the present author by Mr. Harold Cook (cf. Cook, 1928, Pl. 1). One twenty-fifth natural size. Lower tusks wanting.

This young adult skeleton is the finest and most complete *Trilophodon* thus far discovered, including the skull and jaws articulated as in life, with complete tusks marked by a long enamel band extending along the lower external side. Of the trunk and limbs: the scapula, humerus, radius, ulna, pelvis (composite), tibia, fibula, Mtc. III. Of the vertebræ: 7 cervicals, 11 articulated dorsals, 4 lumbars, complete sacrum, and four adjoining caudals; most of the sternum, also ribs of more than one individual. At least three individuals of *Trilophodon* are represented in the skeletal parts found in the same quarry level along with bones of camels, horses, and other animals. *Trilophodon phippsi* is somewhat superior in size to *T. giganteus* Osborn (Fig 257). The principal measurements are:

Greatest length of skull, condyles to tip of premaxillaries	1110 mm.
Greatest depth of skull, condyles to top of occiput	678
Greatest width across zygomatic arches	654
Length of right tusk beyond tip of premaxillaries (outside)	900
Length of M^2	133
Width	85
Length of M^3	216
Width	102
Height of crown of tritoloph above enamel base on M^3	72 mm
Length of mandible	1486
Greatest length of	
Scapula	875
Humerus	772
Radius	648
Femur	1022
Tibia	602
Pelvis, greatest width, over all	1465

preserved at the extremity, not clearly indicating the presence of a pair of small or reduced incisive tusks.

Ainsworth Quarry. This rich quarry near Ainsworth, Brown County, northern Nebraska, first worked in 1927 by Messrs. Morris Skinner and James Quinn for the Colorado Museum of Natural History and by Mr. Carl Sorensen for The American Museum of Natural History, yielded not only the referred cranium and mandible shown in figure 271, but the finest remains of *Trilophodon* thus far discovered in America, together with representatives of the contemporary fauna including camels, horses, etc.

Trilophodon phippsi Cook, 1928. "A New Longirostrine Elephant from Nebraska, Trilophodon phippsi, Sp. Nov." Proc. Colo. Mus. Nat. Hist., Vol. VIII, No. 4, May 1, 1928, pp. 37–43. Type.—An associated skull and jaws, and essentially complete skeleton. Colo. Mus. 1261. Horizon and Locality.—Near Ainsworth, Brown County, Nebraska, in local exposures of the Devil's Gulch beds. Type Figure.—*Op. cit.*, 1928, Pls. I to III (see Figs. 269 and 270 of the present Memoir).

Type Description.—(Cook, *op. cit.*, 1928.1, pp. 38–41) "Type, No. 1261, Colorado Museum of Natural History Fossil Catalog; an associated skull and jaws, and essentially complete skeleton. Specific characters: Differs from *T. giganteus*, Osborn,

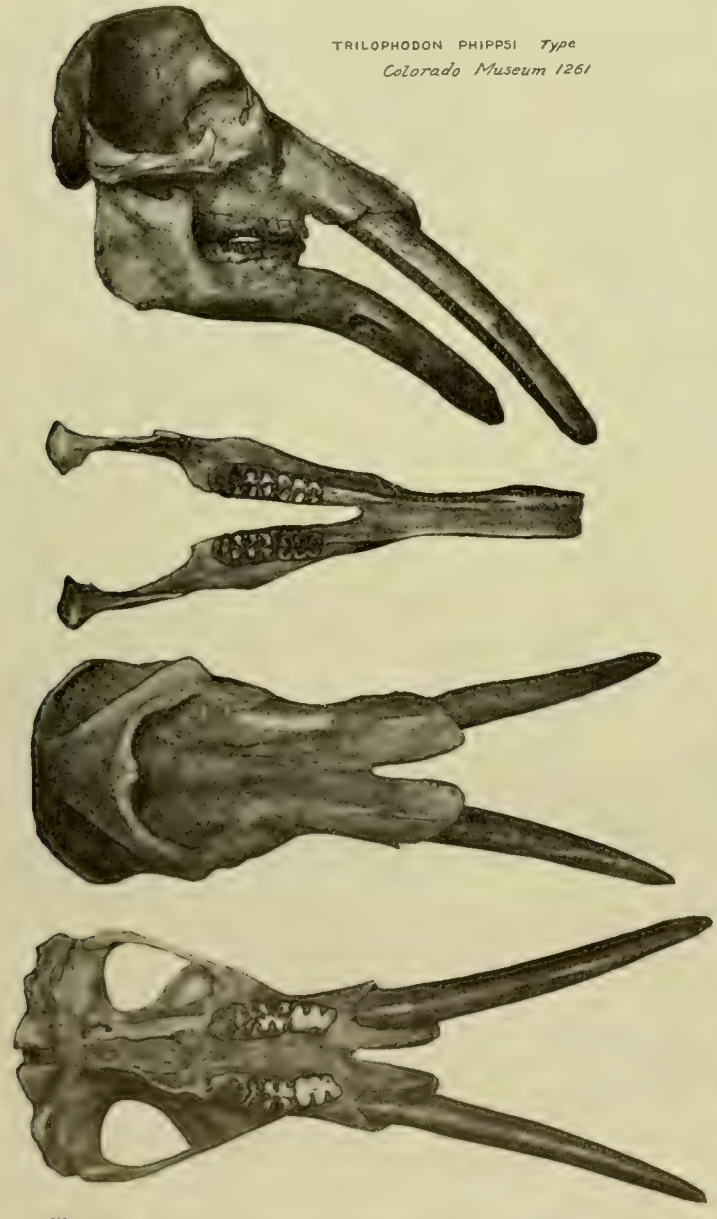


Fig. 270. Type of *Trilophodon phippsi* Cook, 1928. One of the finely preserved skulls from the Ainsworth quarry, Brown County, Nebraska. After photographs kindly furnished the present author by Mr. Harold J. Cook. Approximately one-twentieth natural size.

Fig. 271. *Trilophodon phippsi* ref. (F:A.M. 22411). Cranium and jaws of finely preserved individual in The American Museum of Natural History, agreeing closely in many details with the type cranium (Colo. Mus. 1261). Approximately one-twentieth natural size.

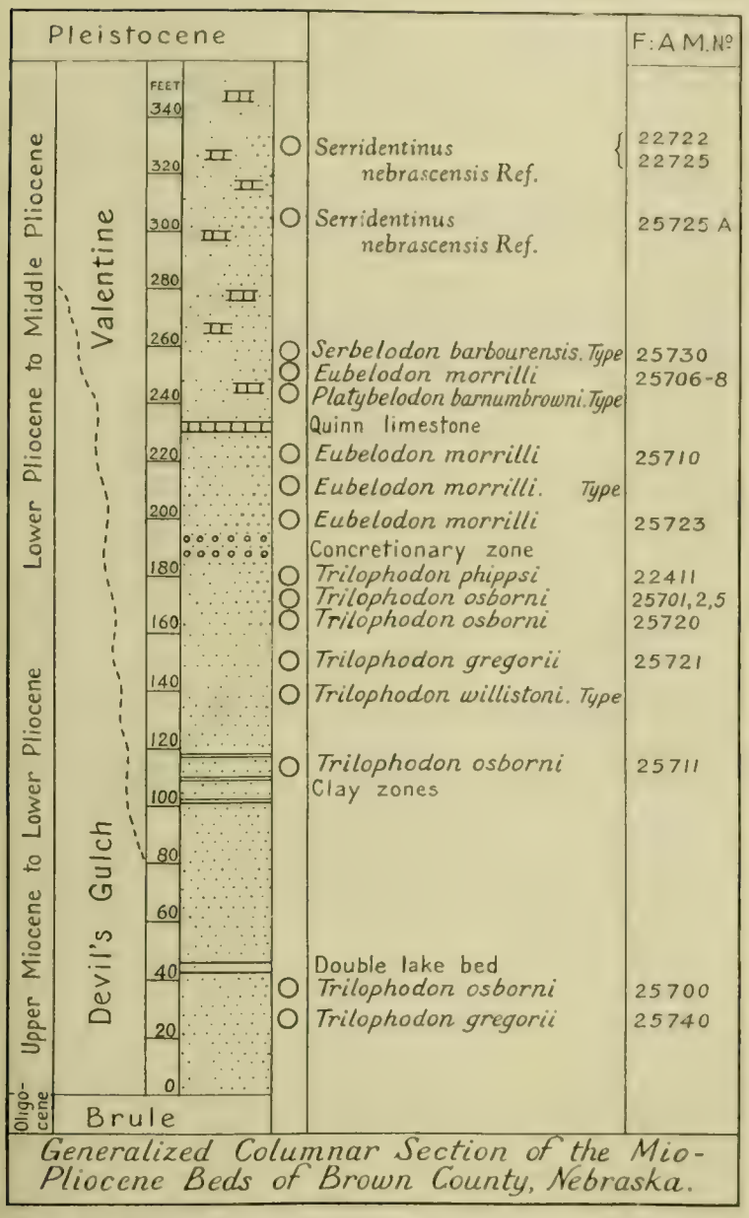


Fig. 272. Vertical distribution of type and referred species of mastodonts of the Mio-Pliocene Devil's Gulch and Valentine sections, as determined in the Frick explorations and collections of the years 1928–1932.

its nearest described relative, in the following characters. Molars slightly more complicated, relatively shorter and broader; enamel band situated differently on tusks; lower jaws without tusks, and with rugose adaptation for digging."

"As comparisons of the width across the condyles to the length from condyles to symphysis will be used again in this paper, the term 'mouth' will be used herein to apply to that area. Reference to the table included [omitted herewith] will show many interesting relations and divergencies. It will be noted that the mouth is exceptionally long and narrow in comparison to all related described types, other than [*Trilophodon*] *giganteus*. In fact it is narrower than any described species of this group, with the exception of *T. paladentatus*, which is very much smaller. In this connection, it may be timely to note that *T. paladentatus* is also a much smaller species than *T. hicksi*, with which it was found closely associated, as reference to the 'mouth' index and comparative measurements herewith will clearly show."

"While other species were developing and using long and efficient lower tusks, in *phippsi* we find a type which had developed an extremely long and heavy symphysis, approximately as long as the tusks and symphysis combined in *paladentatus*, having lost

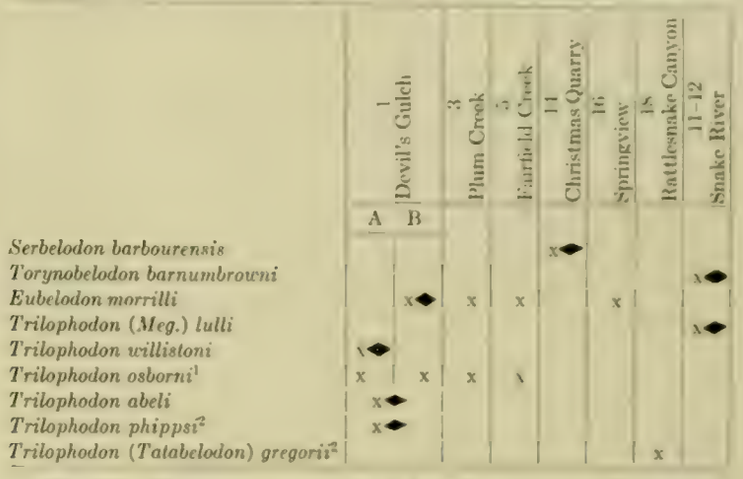


Fig. 273. Key to the intermingling of the Longirostrinæ (*Trilophodon*), Serridentinæ (*Serbelodon*), Platybelodontinæ (*Torynobelodon*), and Humboldtinæ (*Eubelodon*), along the ancient Niobrara River. See map (Fig. 274).

completely all traces of lower tusks, and apparently developed the tip of the lower jaws into an efficient instrument for 'rooting,' in conjunction with the two short upper tusks. . . . In this roughened tip are three short, somewhat rounded grooves, one on each side, and one centrally located. It is possible that these are vestigial remnants of lower tusk alveoli, reminders of ancestors that possessed such tusks; but the centrally located groove makes even this seem questionable. They all end a short distance below the surface of the bone. The expanded, roughened tip strongly suggests a heavy, cartilaginous end on the jaw; and the large mental foramen indicates the need of a great nutritive supply toward the end of the mandible."

"In general, *T. phippsi* was proportioned very like *T. giganteus*, being moderately tall, long bodied, heavily built, and having heavily muscled legs. The most noticeable difference is in the lower jaws, due, primarily, to the difference in development correlated with the presence in one, and absence in the other, of lower tusks."

"The feet are heavy, short and wide, with rugose muscular attachments, as would be expected with such legs. For instance, a comparison of the third digit, front and hind, with that of a modern Indian elephant of about the same height, well illustrates average comparative proportions. The length of metacarpal III in the mature *T. phippsi* is 171 mm., and the width of its distal facet is 82 mm.; the corresponding measurements of the Indian elephant are 194 and 72 mm. Measurements of all digits, front and back, show similar results."

Referred Skull of Trilophodon phippsi from Ainsworth.—This finely preserved skull (F:A.M. 22411) supplements the type skull (Colo. Mus. 1261—Fig. 270) with which it agrees in the absence of lower incisors and in the abruptly truncated symphysis of the lower jaw; no evidence of incisive alveoli. It differs only

[1]Type from Boyd County, Nebraska. [2]Type from "vicinity of Ainsworth." x◆ indicates the type, x the referred specimens.

in the concavity of the facial region, which is due partly to pressure, and in the consequent elongation of the cranial region for support of the superior tusks.

Osborn, 1928: The absence of inferior incisive tusks is so exceptional that it may be considered as an accidental variation or anomaly; if a constant character, it is certainly of specific value. The third inferior molar (ap. 232 mm., tr. 82 mm., index 35) is relatively long and narrow, consisting of four complete ridge-crests and a talon, with conspicuous central or intermediate conules (Fig. 270).

THE PROCAMELUS-HIPPARION ZONE AND PRECEDING AND SUCCEEDING LOWER TO MIDDLE PLIOCENE LIFE ZONES

Equidæ at 'Fort Niobrara' (Fig. 274, No. 6).—The fifteen species of Equines described from 'Fort Niobrara' include species of the more primitive *Parahippus, Merychippus,* and *Hypohippus;* also primitive and progressive species of *Protohippus, Pliohippus,* and *Hipparion,* as below.

Among the camels of Devil's Gulch there occur *Procamelus, Alticamelus, Pliauchenia,* and *Oxydactylus;* among the deer, *Merycodus necatus;* among the carnivores, *Aelurodon, Tephrocyon, Cynarctus, Cyon, Temnocyon,* and an indeterminate mustelid.

The Devil's Gulch section (Fig. 568) extends from the underlying Chadron upward through the *Metoreodon* zone into the *Eubelodon morrilli* zone.

1. *Hypohippus affinis* Leidy
2. *Parahippus cognatus* Leidy
3. *Merychippus calamarius* (Cope)
4. *Merychippus insignis* Leidy
5. *Protohippus niobrarense* (Gidley)
6. *Protohippus simus* Gidley
7. *Protohippus placidus* Leidy
8. *Protohippus perditus* Leidy
9. *Protohippus parvulus* (Marsh)
10. *Pliohippus robustus* Marsh
11. *Pliohippus pernix* Marsh
12. *Pliohippus supremus* (Leidy)
13. *Pliohippus mirabilis* (Leidy)
14. *Hipparion gratum* (Leidy)
15. *Hipparion affine* Leidy

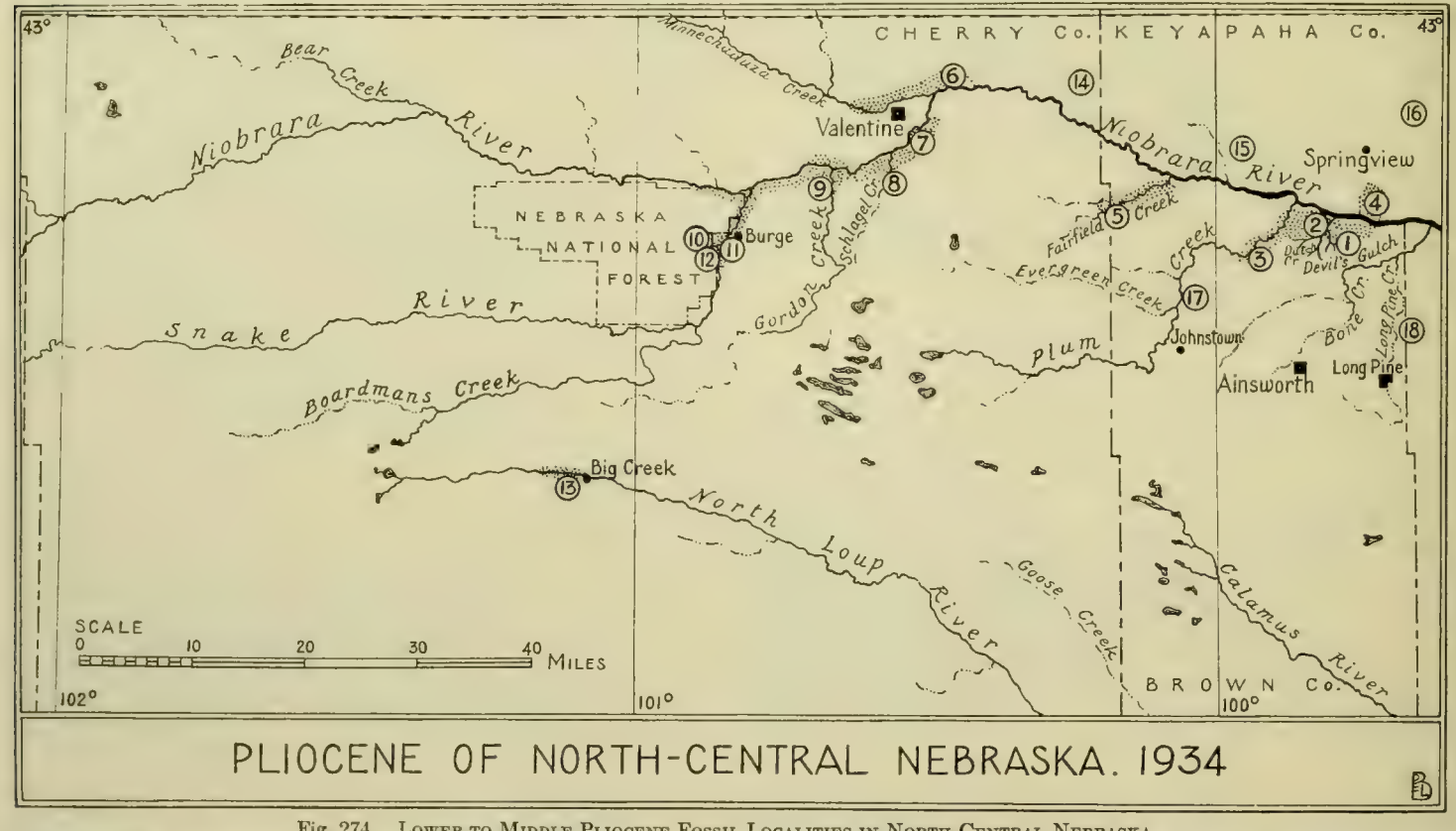


Fig. 274. Lower to Middle Pliocene Fossil Localities in North Central Nebraska

Extending 120 miles east and west, and from 200 to 400 feet above the present level of the Niobrara River. These localities represent the ancient course of the river. Explored (1853-1866) by Meek and Hayden and at intervals up to the present time. The 'Fort Niobrara' (preoccupied) of Leidy, the 'Nebraska' (preoccupied) of Scott, the 'Valentine' of Osborn and Matthew (1909.301), the '*Procamelus-Hipparion* zone' of Osborn (1918.473).

1.	Devil's Gulch	Brown County	Barbour, 1914, 1928-1930 Frick, 1927-1934
2.	Deep Creek	Brown County	Barbour, 1929 Frick, 1927-1933
3.	Plum Creek	Brown County	Barbour, 1928-1930 Frick, 1927-1933
4.	Murphy Canyon	Keyapaha County	Barbour, 1928 Frick, 1927-1933
5.	Fairfield Creek	Brown County	Barbour, 1928-1929 Frick, 1927-1933
6.	Fort Niobrara	Cherry County	Leidy, 1858-1869 Marsh, 1868 Barbour, 1914-1916, 1928-1933
7.	Valentine	Cherry County	Barbour, 1930-1933
8.	Schlagel Creek	Cherry County	Barbour, 1928-1933
9.	Gordon Creek	Cherry County	Barbour, 1928-1933
10.	Steer Creek	Cherry County	Barbour, 1930-1933
11–12.	Snake River	Cherry County	Barbour, 1928-1933
13.	North Loup River	Cherry County	Barbour, 1930
14.	Christmas Quarry	Cherry County	Frick, 1931-1933
15.	Cub Creek	Keyapaha County	Frick, 1927-1933
16.	Springview	Keyapaha County	Frick, 1927-1933
17.	Johnstown	Brown County	Frick, 1927-1933
18.	Rattlesnake Canyon	Brown County	Frick, 1927-1933

16. REVIEW OF THE FRICK COLLECTION OF TRILOPHODONTS, 1924–1933

In the year 1924 Frick discovered the imperfect skull of the species *Trilophodon pojoaquensis* in the Mio-Pliocene marls of Santa Fé, which he described in 1926; with this animal was confused the new Serridentine *Ocalientinus*.

Since Frick's publication of 1926, additional material has been collected by his field parties which proves the existence of *Trilophodon pojoaquensis* in the Santa Fé marls, also of the Serridentine *Ocalientinus ojocaliensis*.

Ten Specimens in the Frick Collection (1924–1932) referable to Species of Trilophodon

In specific order, as arranged by Frick, the Trilophodonts are as follows, omitting the specimens which Osborn refers to the genus *Serridentinus*.[1]

Year	Number	Identification	Character of Specimen	Upper Miocene—Lower Pliocene	Length of Mandible	Measurements M^3	Measurements M_3
1924	F:A.M. 21115	*Trilophodon pojoaquensis* type	Skull	Santa Fé marls, N.M.		197×100 51	
1926	F:A.M. 21139	*Trilophodon pojoaquensis*	Mandible	Santa Fé marls, N.M.	1000a(s)		220×95 43
1929	F:A.M. 21291	*Trilophodon pojoaquensis*	Maxilla and ramus	Santa Fé marls, N.M.		187e	
1931	F:A.M. 21129	*Trilophodon pojoaquensis*	Skull	Santa Fé marls, N.M.		201×102 51	
1930	F:A.M. 21300	*Trilophodon cruziensis* type	Skull and mandible	Santa Fé marls, N.M.	1000(s)	165×72 44	180×71 39
1929	F:A.M. 21290	*Trilophodon cruziensis*	Maxilla	Santa Fé marls, N.M.		165	180×70 39
1930	F:A.M. 21296	*Trilophodon (Amebelodon) joraki* type	Mandible	Santa Fé marls, N.M.	1130a(s)		180×65 36
1928	F:A.M. 25702	*Trilophodon osborni*	Mandible	Ainsworth, Neb.	1130(s)		207×78 37
1932	F:A.M. 25721	*Trilophodon osborni*	Skull	Ainsworth, Neb.		178×85 48	
1928	F:A.M. 25711	*Trilophodon osborni*	Skull and mandible	Ainsworth, Neb.	1260	187×85 45	201×89 44
	Colo. Mus. 1261	*Trilophodon phippsi* type	Skull and mandible	Ainsworth, Neb.		216×102 47	
	F:A.M. 20850B	*Trilophodon barstonis* type [=*Serridentinus*]	Dp^3 (45×34)	Barstow, Cal.			
	F:A.M.20850A	*Trilophodon barstonis* type [=*Ser.*]	P_4 (40.5×33)	Barstow, Cal.			

In column of mandibular lengths, "a" indicates approximate, "s" to end of symphysis only.

Indices.—The ten specimens of *Trilophodon* in the Frick Collection present *superior indices* ranging from 44 to 51, partly modified by lateral pressure; the *inferior indices* range from 36 to 44, as shown in the accompanying table.

[1](1935) *Trilophodon barstonis* now referred to *Serridentinus*.

Conclusions as to Species.—It is not the purpose of this Memoir to determine specific differences among the Trilophodonts but to note the outstanding characteristics of the type specimens as presented by the various authors.

It appears probable that these ten Trilophodonts in the Frick Collection, chiefly of Upper Miocene and Lower Pliocene age, represent in part males and females of species, the differences in the type and referred specimens being due partly to age, partly to sex.

Trilophodon pojoaquensis Frick, 1926

Figures 275, 276, 278

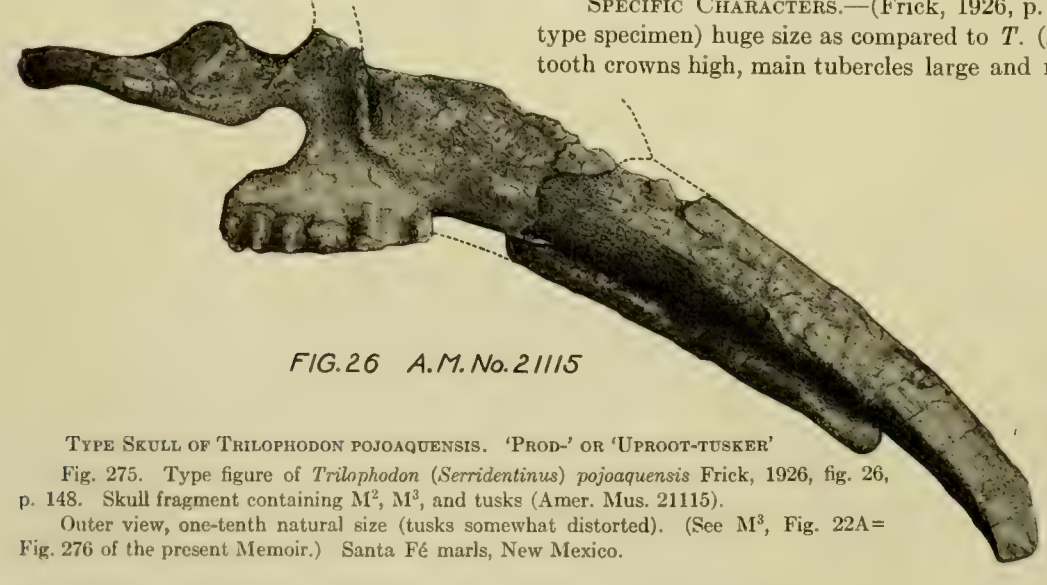
Santa Fé marls, Santa Fé County, New Mexico. Mio-Pliocene.

This new Trilophodont (*Trilophodon pojoaquensis* Frick) is in a stage of evolution not far from that of *Trilophodon osborni* Barbour and appears to establish a Lower Pliocene age for these two species. The author's figures are reproduced and renumbered for this Memoir.

Most welcome is the discovery (1924) and description (1926) by Mr. Childs Frick of a fine type maxilla and tusks (Amer. Mus. 21115) from the Mio-Pliocene Santa Fé marls of Santa Fé County, New Mexico, an horizon which originally yielded the type of *Mastodon* [=*Serridentinus*] *productus* Cope and in 1924–1931 other valuable material of this species.

The author's original references and type description are as follows:

Trilophodon (*Serridentinus*) *pojoaquensis* Frick, 1926. "Tooth Sequence in Certain Trilophodont Tetrabelodont Mastodons and *Trilophodon* (*Serridentinus*) *pojoaquensis*, new species." Bull. Amer. Mus. Nat. Hist., Vol. LVI, Art. II, pp. 125, 142–150, 161, 162–165. Type.—(*Op. cit.*, p. 161): "Fragment of skull containing m^2-m^3 of left side, and both tusks." Amer. Mus. 21115. Horizon and Locality.—Mio-Pliocene, Santa Fé marls, about twenty-four miles north of Santa Fé, Santa Fé County, near Pojuaque (the pueblo for which the species was named), New Mexico. Type Figure.—*Op. cit.*, fig. 26, p. 148, and fig. 22A, p. 144.



Type Skull of Trilophodon pojoaquensis. 'Prod-' or 'Uproot-tusker'

Fig. 275. Type figure of *Trilophodon* (*Serridentinus*) *pojoaquensis* Frick, 1926, fig. 26, p. 148. Skull fragment containing M^2, M^3, and tusks (Amer. Mus. 21115).

Outer view, one-tenth natural size (tusks somewhat distorted). (See M^3, Fig. 22A= Fig. 276 of the present Memoir.) Santa Fé marls, New Mexico.

Description of Type Specimen (Amer. Mus. 21115, Fig. 275).—(Frick, 1926, pp. 161, 162): "The specimen exhibits a portion of the left maxilla and adjacent region containing m^2-m^3 (cracked) and tusks of large size. The m^3, which is slightly worn, in anteroposterior diameter exceeds by 40 per cent the estimated length of the hypothetical m^3 of the type of *T.* (*S.*) *productus*. Except for its much greater size and perhaps more massive tubercular arrangement, the tooth broadly resembles the last molars referred to the latter species. This molar, and a broken m_3 (Amer. Mus. 21122A), that implies a tooth of equal size to that of the huge type specimen of *T.* (*S.*) *floridanus*, represent the largest individuals in the Santa Fé collection. The tusks, which have been much shortened through use, are of heavy triangular-tending cross-section and have on the outer side a broad band of enamel. The particular specimen, on account of its extraordinary size, has been selected for the type of the new species, the much better preserved but somewhat smaller skull being made a paratype."

(Osborn, 1933): The smaller skull (F:A.M. 21125), originally considered by Frick as a paratype of *Trilophodon pojoaquensis*, proved on subsequent examination and study by Frick (1933, p. 579) to be referable to his new Serridentine genus and species *Ocalientinus ojocaliensis;* it is accordingly figured (Figs. 402 and 405) and described (pp. 435–439) in Chapter X, of the present Memoir, the Serridentinæ.

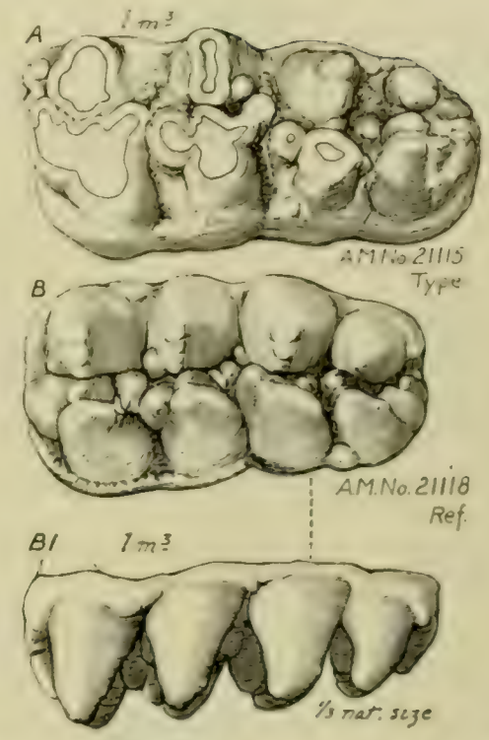
Specific Characters.—(Frick, 1926, p. 161): "(As seen in type specimen) huge size as compared to *T.* (*S.*) *productus* Cope; tooth crowns high, main tubercles large and resultingly crowded, three-crested intermediate molars wearing to single trefoils, four-crested last molars with slight tuberculate heels, and m^3 greatly elongate relative to m^2; mature cheek-tooth series consisting of $m\frac{2}{2}$-$m\frac{3}{3}$; large downwardly directed superior tusks with broad band of enamel on outer surface."

Comparison with Trilophodon osborni.—Osborn, 1926: The measurements below from Frick (1926) and Barbour (1916), together with a comparison of the crania and grinding teeth of the two species, indicate that *Trilophodon pojoaquensis* is in a stage of evolution slightly more progressive than *T. osborni*. Closely comparing the figures of the third superior grinding teeth in the two types (Fig. 251, *T. osborni*, and Fig. 276, *T. pojoaquensis*), we observe their similar size and a similar development of the internal trefoils, while *T. pojoaquensis* exhibits somewhat stronger external trefoil rudiments and a more pronounced rudiment of a pentaloph, the length of the third superior molar being 197 mm. as compared with 185 mm. in *T. osborni*. Both *T. pojoaquensis* (Fig. 275) and *T. osborni* (Fig. 253), are very clearly distinguished by the broad external enamel band on the out- and downcurved tusks, which are of moderate length as compared with the slightly downcurved tusks of *T. giganteus* in which the enamel band is seen on the lower border of the tusks only (Fig. 259), also as compared with *T. lulli* (Fig. 243) in which the tusks are greatly elongated and nearly horizontal in position.

Consequently we infer that *Trilophodon osborni* and *T. pojoaquensis* represent a Lower Pliocene stage of evolution; *T. pojoaquensis* is a somewhat more progressive species than *T. osborni* and represents a slightly more recent geologic stage.

Comparative Measurements

	Trilophodon pojoaquensis Frick	*Trilophodon osborni* Barbour
Length, third superior molar, M^3, type	197	185
Length, second superior molar, M^2, type	[140]	130



A, Type Molar of Trilophodon pojoaquensis and B, B1, Referred Molar of Ocalientinus ojocaliensis

Fig. 276. (Upper) Type figure of third superior molar (Amer. Mus. 21115) of the left side, l.M^3, of *Trilophodon (Serridentinus) pojoaquensis* Frick, 1926, p. 144, fig. 22A, one-third natural size.

(Lower) Crown and side views of referred third left superior molar l.M^3 (Amer. Mus. 21118) of *Ocalientinus ojocaliensis* (Frick, 1926, pp. 144, 145, fig. 22B; 1933, fig. 26, see caption, p. 563). One-third natural size.

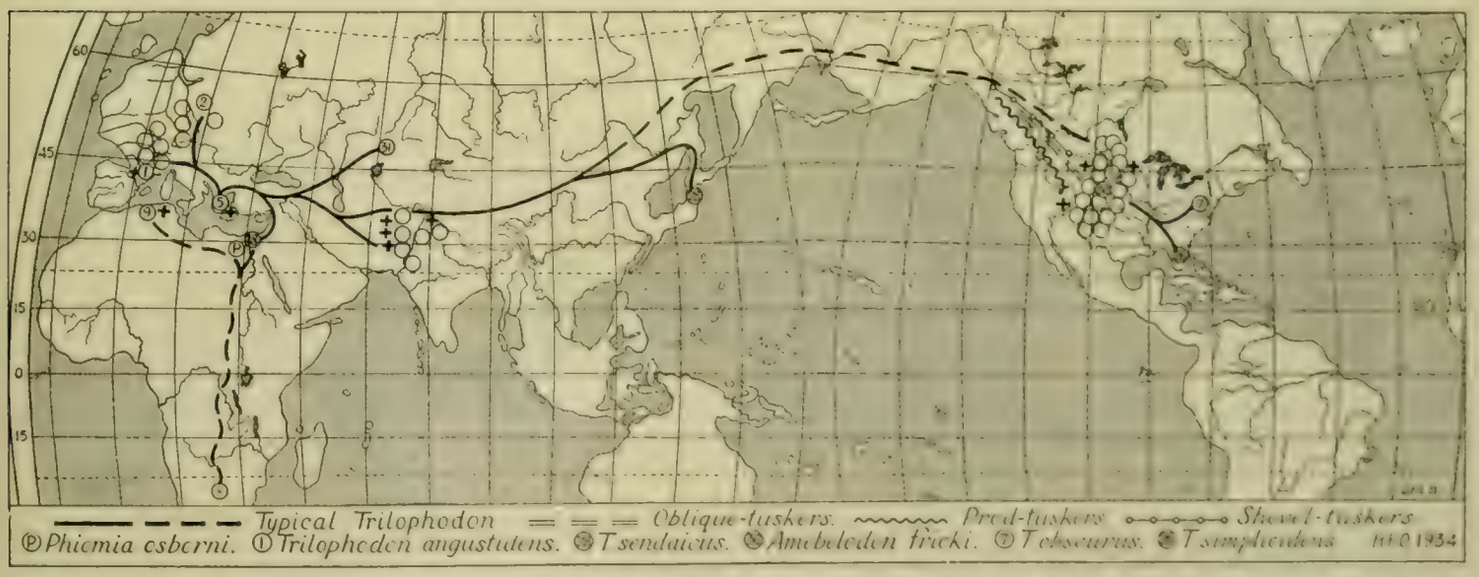


Fig. 277. World migration lines of the typical *Trilophodon* (1–*T. angustidens*), of the 'shovel-tuskers' (P and 9 – *Phiomia*, 30 – *Amebelodon*), of the 'prod-tuskers' (28–*T. sendaicus*, 7–*T. obscurus*, 26–*T. simplicidens*), from Africa (theoretical), Eurasia, India, and North America.

SUPPLEMENTARY NOTES ON TRILOPHODON POJOAQUENSIS FRICK, 1926, 1933

Of the specimens of *Trilophodon pojoaquensis* listed by Frick in his paper of 1933, pp. 578, 579, 585, the largest skull (F:A.M. 21129) is found to be a true *Trilophodon* and is figured in the present Memoir (Fig. 278); other specimens, namely, F:A.M. 21139 and 21291, also belonging to *T. pojoaquensis*, are not figured either by Frick or Osborn. F:A.M. 21139, has lower tusks, of the 'prod-tusker' type; these are seemingly round in cross-section, but with a depression or groove along their upper surfaces, which may be partly due to crushing.

In 1926, p. 161, Frick first described and named the species *Trilophodon* (*Serridentinus*) *pojoaquensis*, basing it on the "fragment of a skull containing m^2-m^3 of left side, and both tusks. Amer. Mus. 21115." A complete résumé of his description, together with type figure, is given on pages 320, 321, figs. 275, 276, of the present chapter. At the same time he described as a paratype a superb skull (Amer. Mus. 21125) from the same locality as the type, namely, the Santa Fé marls of New Mexico, which in his recent paper (1933) he has referred to his new genus and species *Ocalientinus ojocaliensis*. The present writer confirms this reference and the reader

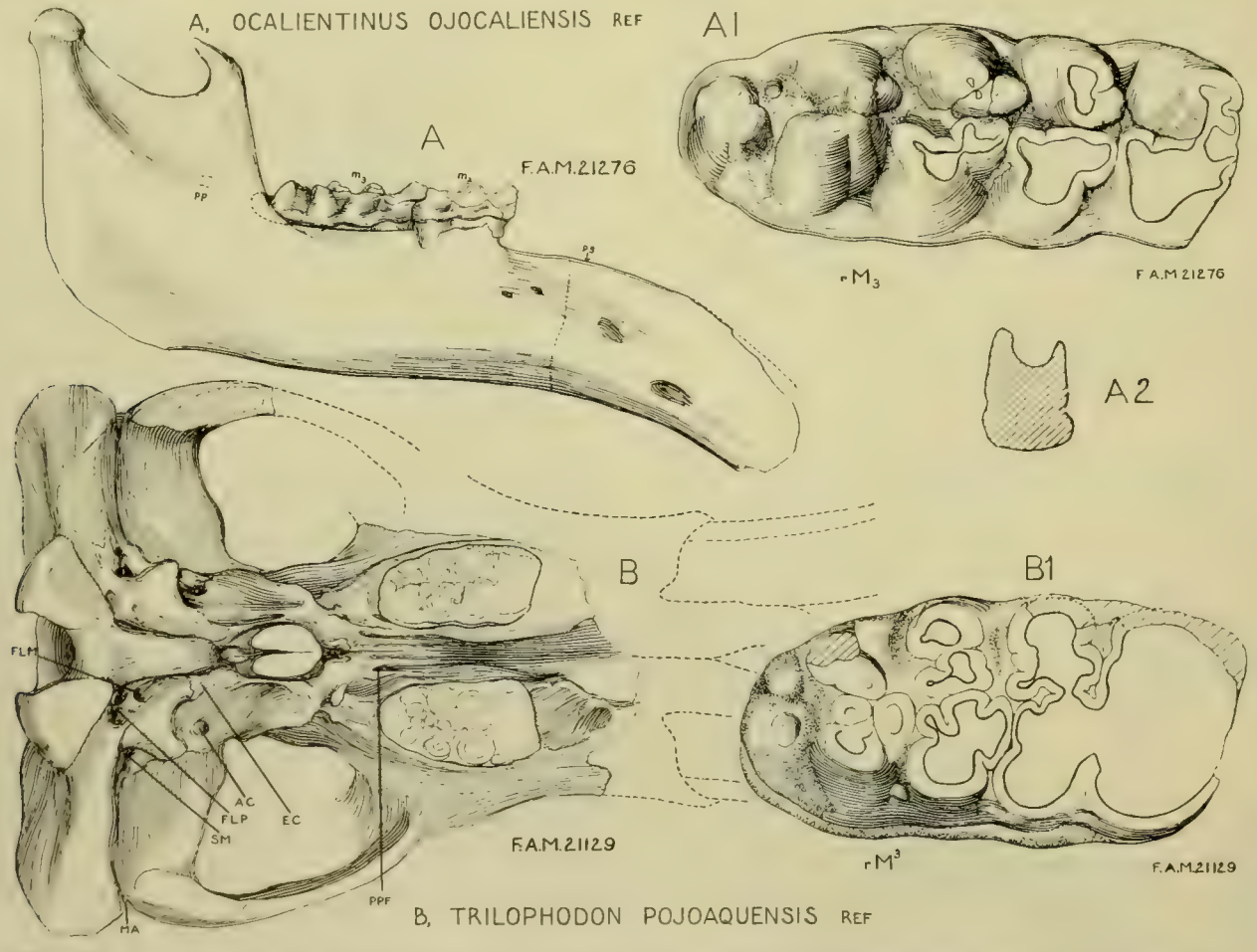


Fig. 278. Long-jawed Trilophodon pojoaquensis Frick and Ocalientinus ojocaliensis Frick, 1933, Frick Collection, Santa Fé Marls, Tusuque and Santa Cruz, New Mexico (cf. Figs. 275, 276)

A, *Ocalientinus ojocaliensis* Frick. Referred mandible (F:A.M. 21276), length 1200+mm., from Tusuque, N. M. After Frick, 1933, fig. 6, p. 531, one-tenth natural size.

A1, Same, third right inferior molar, r.M_3, with 4–5 ridge-crests, ap. 225 mm., tr. 88 mm., index 39, about one-third natural size.

B, *Trilophodon pojoaquensis* Frick. Largest cranium (F:A.M. 21129), from Santa Cruz, N. M. After Frick, 1933, fig. 12B, about one-tenth natural size. Zygomatic width 700 mm.

B1, Same, third right superior molar, r.M^3, with 4½ ridge-crests, ap. 201+mm., tr. 100 mm., index 50. After Frick, 1933, fig. 23B, about one-third natural size.

will find a review of the specimen on the pages (pp. 435–439, Chap. X) mentioned above under *Trilophodon* (p. 320), the genus to which it was first referred, although it is designated as *O. ojocaliensis* ref. Also referable to *O. ojocaliensis*, rather than to *Trilophodon*, is the tuskless mandible from Tusuque, N. M. (F:A.M. 21276), figured on page 322 as figure 278A–A2, which Frick provisionally referred to *Serridentinus pojoaquensis*.

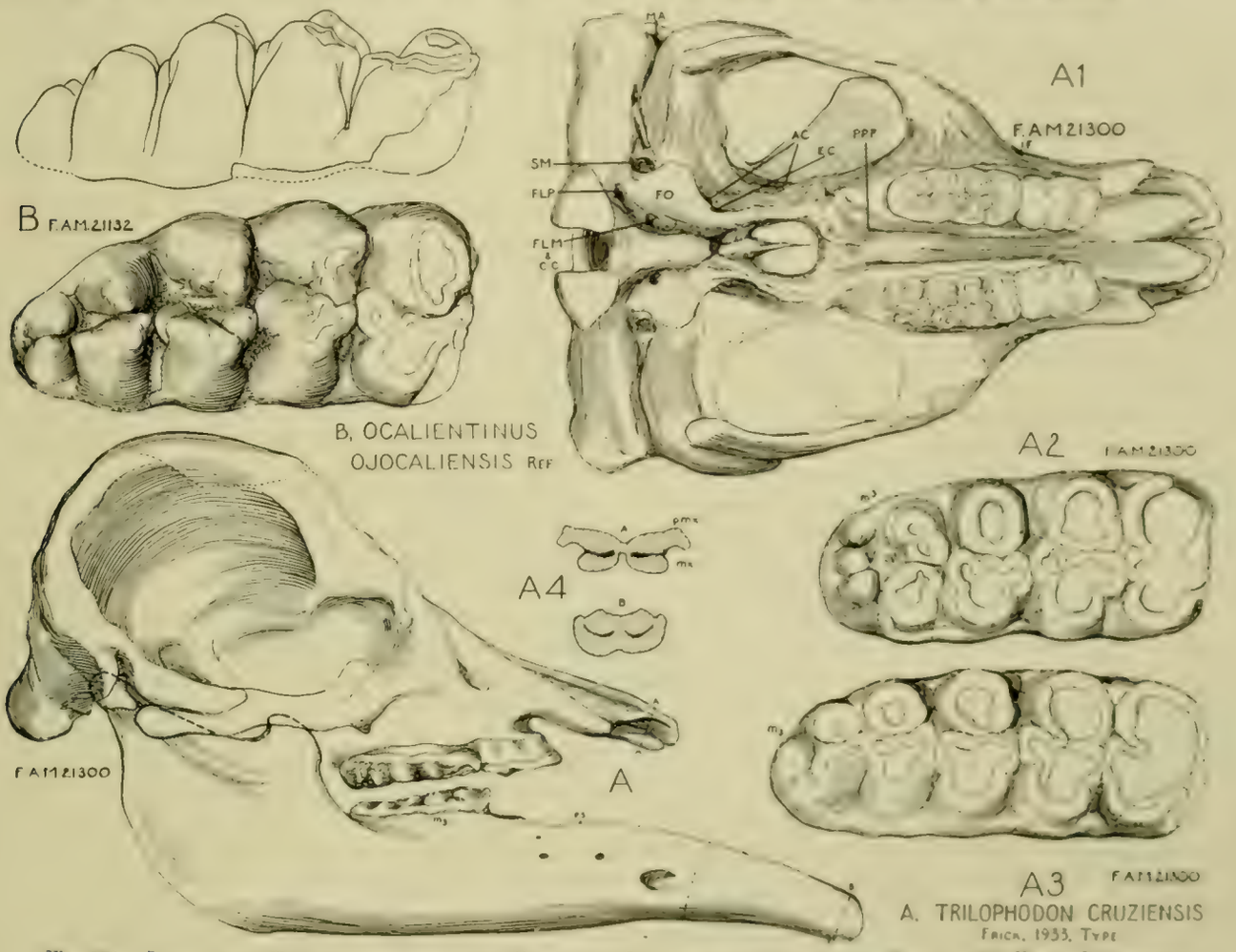


Fig. 279. Long-jawed Trilophodon cruziensis Frick and Ocalientinus ojocaliensis Frick, 1933, Frick Collection, Santa Fé Marls, Mio-Pliocene, Santa Cruz, New Mexico

After Frick, 1933, Figs. 10, 12A, 25

Cranium and mandible, one-ninth natural size; molars, one-third natural size

A, *Trilophodon cruziensis* Frick. Type female cranium and mandible devoid of tusks (F:A.M. 21300), with superior and inferior incisive alveoli (A——A, B——B) partly closed, lower incisive rostrum reduced. After Frick, 1933, fig. 10.

A1, Palatal aspect of same cranium (F:A.M. 21300), after Frick, 1933, fig. 12A.

A2, Same, third superior molar, r.M^3, 4½ ridge-crests, ap. 165 mm., tr. 72 mm., index 44.

A3, Same, third right inferior molar, r.M_3, 5½ ridge-crests, ap. 180 mm., tr. 71 mm., index 39.

A4, Transection of edentulous premaxilla (A) and of rostrum of mandible (B).

B, *Ocalientinus ojocaliensis* Frick. Referred third right inferior molar, r.M_3, 4½ ridge-crests (F:A.M. 21132), ap. 194 mm., tr. 89 mm., index 46. After Frick, 1933, fig. 25.

Trilophodon cruziensis Frick, 1933

Figures 279, 281

From Santa Cruz, New Mexico. Mio-Pliocene. Santa Fé marls.

Compare *Trilophodon phippsi* Cook, 1928, also *Trilophodon joraki* Frick, 1933, both tuskless in the lower jaw, possibly females.

Trilophodon cruziensis Frick, 1933. "New Remains of Trilophodont-Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, pp. 505, 509, 574, 576, 579, 584, 585. Type.—(*Op. cit.*, p. 579): "Fine tuskless low-domed skull and mandible with m^2–m^3; 2 scapulæ, 2 humeri, and partial hyoid. $m^3 = \frac{(165)}{180}$ mm. F:A.M. 21300. Figured this paper, *Figs. 10, 12A, 17, 23A and 25.*" Horizon and Locality.—Santa Cruz, New Mexico, Santa Fé marls, Mio-Pliocene. Collected in 1930. Type Figure.—*Op. cit.*, figs. 10, 12A, 17, 23A, and 25.

Specific Characters.—(Frick, 1933, p. 579): "Cranium relatively low, elongate narrow symphysis of moderate to long Longirostrine proportions. The narrow, elongate-tending m_3 with incipient fifth crest is not unsuggestive of *Eubelodon*." Length

of humerus 600 mm. Frick observes (p. 574) that this "low-domed, tuskless cranium with tuskless jaws of specimen F:A.M. 21300 (Fig. 10 [Fig. 279 of Memoir]) is interpreted as possibly representing the female of a normal, moderately elongate jawed, low-browed species."

Osborn, 1933: The mandibular chart (Fig. 281) below presents a significant comparison of the type mandibles of *Trilophodon cruziensis* and *T. joraki*. These mandibles are recorded (Frick, 1933) from the same geologic horizon, namely, the Santa Fé marls, Santa Cruz, New Mexico; they agree in the proportions and characters of the jaw; they agree in the proportions of the third inferior molars; they agree in the absence of inferior incisive teeth, the alveoli being partly closed in each case. Consequently it appears probable that they belong to the same species, namely, *T. cruziensis* which anticipates *T. joraki* in description. This edentulous condition of the inferior ramus has also been observed in the type of *T. phippsi*, so that these two specimens may prove to be referable to *T. phippsi* Cook, 1928.

Trilophodon (Tatabelodon[1]) riograndensis Frick, 1933

Figure 280

From Battleship Mountain, New Mexico. Santa Fé marls, Mio-Pliocene.

The author speaks of the longirostral Mio-Pliocene Trilophodonts (*Tatabelodon*) as 'buffer-tuskers' [='prod-tuskers'].

Tatabelodon riograndensis Frick, 1933. "New Remains of Trilophodont-Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, pp. 505, 509, 534, 535, 547, 571, 573, 576, 581, 585. Type.—(*Op. cit.*, p. 576): "Crushed maxilla and mandible, F:A.M. 21140 (*Figs. 6 and 13*). Symphysis bearing bases of extremely heavy incisors, roots extending posterior to p. s.; symphysial length while indeterminate evidently considerable. . . . [p. 581] Type.—Mandible with m_3s and extremely heavy incisor bases, distal end of symphysis missing. $m_3 = 199$ mm. right, 203 left." Horizon and Locality.—From Battleship Mountain, New Mexico; Santa Fé marls, Mio-Pliocene. Type Figure.—*Op. cit.*, figs. 6 and 13.

Specific Characters.—(Frick, 1933, p. 581): "Characterized by the extreme heaviness, indentation and posterior position of the incisor root, unusual lightness of posterior mandible relative to symphysis and apparent tendency to deflection of symphysis. In the referred Nebraskan species the mandibular symphysis is of peculiar form, the inferior incisors are elongate and of extremely massive cross-section, and the upper tusks are large, with wide bands."

Geologic Age.—(Frick, 1933, p. 571): "The mastodont forms of the Ojo Caliente and the Santa Cruz sections of the Santa Fé basin are tentatively interpreted as of the *Hipparion* zone. Probably of as fully as late age is the peculiar type mandible of *Tatabelodon riograndensis*, n.g. and sp., discovered in place directly beneath the burnt rhyolitic contact in Battleship Mountain [Footnote: 'See writer's photograph of this specimen in cinches, and members of Joseph Rak's 1926 field party, including the discoverer of the specimen, Charles Christman, reproduced, opposite page 199, in 'Cope: Master Naturalist,' by H. F. Osborn, 1931.']."

Trilophodon (Tatabelodon[1]) gregorii Frick, 1933

Figure 280

From the vicinity of Ainsworth, Nebraska. Lower Pliocene.

Tatabelodon gregorii Frick, 1933. "New Remains of Trilophodont-Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, pp. 506, 509, 534, 536, 581, 590, 591, 593, 597, 598. Type.—(*Op. cit.*, p. 597): "Type.—Palate with m^2-m^3, tusks, and partial mandible with m_3 and heavy incisor. $\frac{\text{p. p.-p. s.}}{\text{ant. symp.}} = (100)\%$ $m^3 = (190)$ mm. $m_3 = (205)$. F:A.M. 25740." Horizon and Locality.—From vicinity of Ainsworth, Nebraska. Lower Pliocene. Type Figure.—*Op. cit.*, figs. 13 and 27A.

Specific Characters.—(Frick, 1933, p. 597): "The superior tusks are proportionately as heavy as the inferior incisor, tending to be round in cross-section and strongly curved, and are provided with a broad band of enamel [67 mm.]. The preserved inferior incisor is of the same extremely heavy cross-section of the genotype [*Tatabelodon riograndensis*], in this being partially suggestive of the Honduras genotype of *Aybelodon*, n.g. In the mandible the superior lateral margin of the symphysial gutter exhibits a marked flare; the usual weakness of symphysis occurs in the vicinity of the major mental foramina and the incisive root bases; superior to the incisive roots (see cross-section) there is an inverted triangular area free of bone; the depression in the vertical ramus posterior and inferior to the coronoid process is considerably less than in the New Mexican genotype, F:A.M. 21140."

Materials.—Frick (p. 598 and fig. 12C) questionably refers to *Tatabelodon gregorii* a palate from Rattlesnake Canyon, near Ainsworth, Nebraska (F:A.M. 25721), characterizing it as follows:

"Questionably Referred.—Palate with m^2-m^3 (erupting) and sections of right and left curved tusks with enamel bands narrowing posteriorly. Posterior palate peculiarly 'bridged' over. $m^2 = 123$ mm. $m^3 = 180$ (erupting). Molars lighter and slenderer transversely and tusks lighter than in F:A.M. 25740." This specimen is referred by Osborn to *Trilophodon osborni*.

Trilophodon (Tatabelodon) riograndensis			Character of Specimen	Length of Mandible	M^3	M_3
1926	F:A.M. 21140 type	Battleship Mt., N.M.	Mandible	1000a		203×82 40
Trilophodon (Tatabelodon) gregorii						
1932	F:A.M. 25740 type	Ainsworth, Neb.	Skull and mandible		190×95 53	205×89 43

[1](Frick, letter, Sept.26, 1933): "*Tatabelodon—T-ata belodon*—ancestral or primitive 'belodon.' The initial 'T' of the last two subgenera [*Trobelodon* and *Tatabelodon*] recalling the 'T' of *Trilophodon* with which the two were grouped in the 'Longirostrines' proper." (See Frick, 1933, p. 576.)

Osborn, 1933: The superiorly grooved and upcurved longirostral symphyses of these types scarcely serve for generic distinction from *Trilophodon* to which they appear to be related both in length of jaw and in the dimensions of the 4½ ridge-crested third inferior grinding teeth, as shown in the above comparative table.

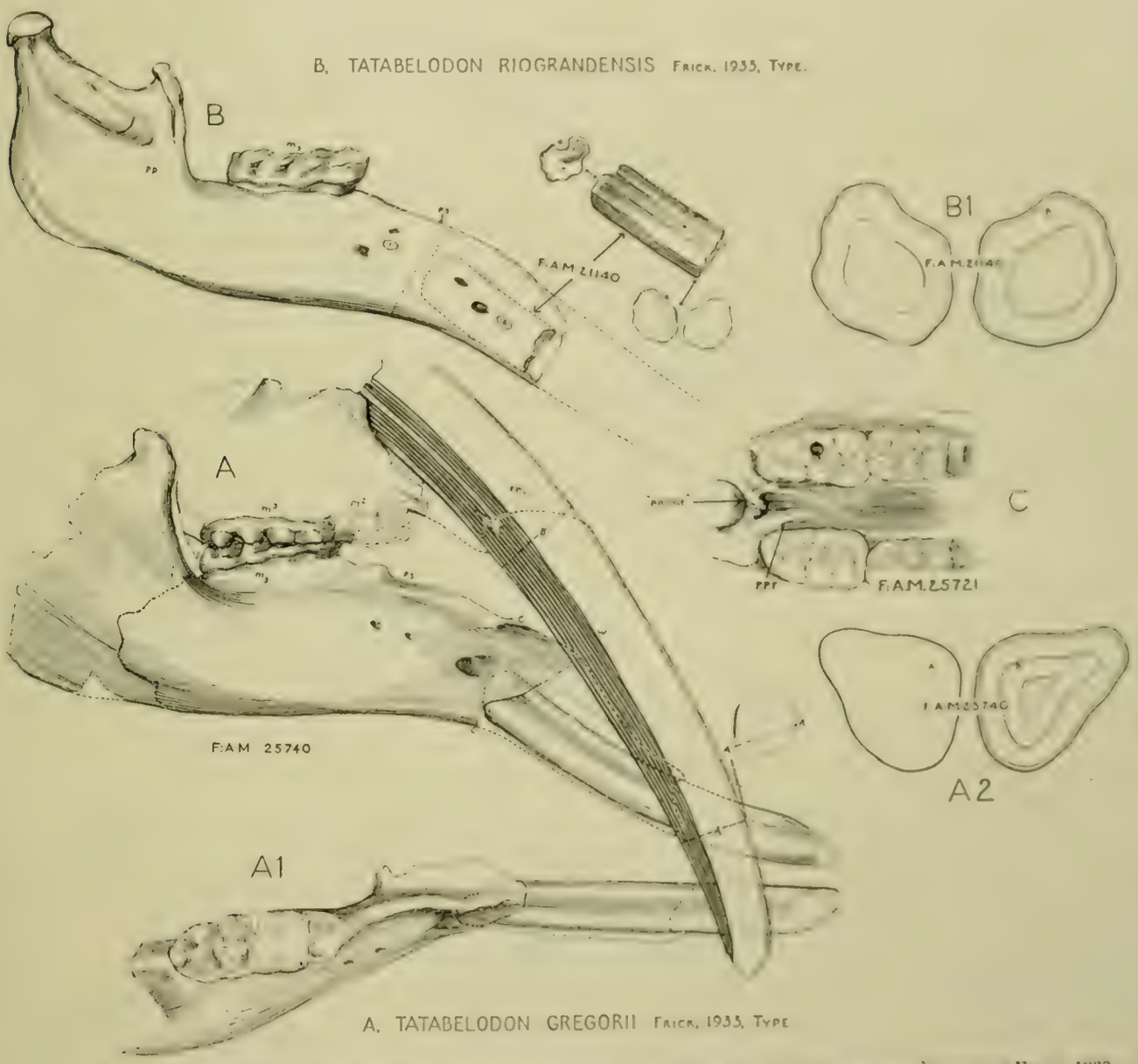


Fig. 280. 'Prod-tuskers': Trilophodon (Tatabelodon) riograndensis Frick and T. (Tatabelodon) gregorii Frick, 1933, Frick Collection, Battleship Mountain, New Mexico, and Ainsworth, Nebraska

Mandibles about one-tenth natural size

B, *Tatabelodon riograndensis* Frick. Genotype mandible (F:A.M. 21140), length 1000a mm., from Battleship Mountain, New Mexico. After Frick, 1933, fig. 6.

B1, Transection of inferior tusks of same, after Frick, 1933, fig. 13.

A, *Tatabelodon gregorii* Frick. Type cranium and mandible (F:A.M. 25740), from near Ainsworth, Nebraska. After Frick, 1933, fig. 27A.

A1, Crown view of mandible of same.

A2, Triangular sections (A, B) of inferior incisive tusks of same.

C, Palate (F:A.M. 25721) referred by Frick (1933, fig. 12C) to *Tatabelodon gregorii*, by Osborn (in the present Memoir) to *Trilophodon osborni*. From Rattlesnake Canyon, near Ainsworth, Nebraska.

Trilophodon joraki[1] Frick, 1933

Figure 281A

From Santa Cruz, New Mexico. Santa Fé marls, Mio-Pliocene.

Compare *Trilophodon phippsi* Cook, 1928, also *T. cruziensis* Frick, 1933, both with tuskless lower jaws resembling the tuskless *T. joraki* type. See also Fig. 245, p. 297 above.

(?) *Amebelodon joraki* Frick, 1933. "New Remains of Trilophodont-Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, pp. 505, 509, 515, 536, 554, 557, 577, 582, 585. TYPE.—(Frick, *op. cit.*, p. 582): "Tuskless mandible with m_3s. F:A.M. 21296. Figured this paper, *Fig. 18.* m_3 (much worn) = ((180+))[2] mm. Characterized by elongation (122–127%) and considerable breadth of symphysis and anterior position of main mental foramen, etc." HORIZON AND LOCALITY.—From Santa Cruz, New Mexico. Collected in 1930. TYPE FIGURE.—*Op. cit.*, 1933,fig. 18 (Fig. 281A of the present Memoir).

Frick in his paper of 1933, under the heading "Résumé of Three Symphysial Groups and Seven Tentatively Recognized New Mexican Longirostrine Species," page 575, places *Amebelodon joraki* in his Group C, characterized as follows (p. 577):

"C. Symphysis Very Long—'Superlongirostrines' [Symphysis approximating 120+% of the post symphysis—pouch length.] The group is represented in the New Mexican collection by two or more forms which differ greatly in the relative size and shape of the inferior incisors. The characters of the superior tusks are unknown.

Species 7. (?) *Amebelodon joraki*, n. sp. TYPE.—Mandible with extremely elongate and tuskless symphysis, F:A.M. 21296 (*Fig. 18*). m_3 = ((180))[2] mm. [Note partial resemblance of symphysis to that of larger tuskless mandible from Nebraska referred to *Eubelodon.*]"

Osborn, 1933: The mandibular measurement (1130a mm.) is within the range of the Trilophodonts of the Santa Fé marls and of Ainsworth and identical with that of the ramus referred to *Trilophodon osborni*, namely, 1130 mm. The single inferior grinding tooth (ap. 180 mm., tr. 65 mm., index 36) is also close in measurement to that of the type of *Trilophodon cruziensis*, namely, ap. 180 mm., tr. 71 mm., index 39.

As noted above under the description of *Trilophodon cruziensis*, the type of *T. joraki* Frick (F:A.M. 21296) is in some respects similar to the type of *T. cruziensis* (F:A.M. 21300) also, in the absence of inferior incisive teeth, to the type of *T. phippsi* Cook, 1928 (Colo. Mus. 1261). It is accordingly to be considered whether both *T. joraki* and *T. cruziensis* may not be referable to *T. phippsi.* The tuskless condition of *T. joraki* is probably a female character. As shown in the table above (p. 319), the mandibles in the Frick Collection referred to *T. pojoaquensis*, *T. cruziensis*, *T. joraki*, and *T. osborni*, range in length from 1000a mm. to 1260 mm., partly attributable to age, partly to sex.

The female sex of the tuskless type of *Trilophodon cruziensis* is apparently indicated by the minimum measurements both of the jaw (1000 mm.) and of the superior and inferior grinding teeth. The third superior molars range from 165 mm. to 216 mm. The supposed female *T. phippsi* type presents a relatively large M^3 (ap. 216 mm.).

In figure 281 below an interesting comparison is made of the admirable series of drawings in Frick's paper of 1933 of the superior view of the mandibles of the two species *Trilophodon joraki* and *T. cruziensis* in contrast with those of *Ocalientinus*, *Serridentinus*, and *Trobelodon;* there can be no doubt that *Trilophodon* is clearly distinguishable by the five crested third inferior molars exhibiting the central trefoil expansions and well developed central conules which are absent in the Serridentines.

Osborn, 1935: Compare tuskless mandible recently found near the type locality of *Trilophodon* (*Megabelodon*) *lulli* (Fig. 245, p. 297 above).

COMPARISON OF MANDIBLES OF TRILOPHODON, OCALIENTINUS, SERRIDENTINUS, AND TROBELODON

The mandibular drawings reassembled from Frick's paper of 1933, as shown in similar scale and similar aspect in figure 281, enable us clearly to distinguish the outstanding mandibular and dental characters of two species of *Trilophodon* (A, B), of one species of *Ocalientinus* (C), of two specimens of *Serridentinus productus* (D, E), and of the genotype specimen of *Trobelodon* (F) transferred (1933) to the Serridentinæ (Chap. X).

First we notice the very marked distinction in the characters of the third inferior molar, namely: (1) In *Trilophodon* (A, B) this tooth is long, narrow, and five crested; in contrast (2) to the three members of the subfamily Serridentinæ (C, D, E, F), in which the third inferior molar is 4½ ridge-crested with ectotrefoil spurs; *Ocalientinus ojocaliensis* (C) is very clearly distinguished by the elongation of the symphysis and deep superior grooves, while its lower incisors present broadly transverse blunted extremities, similar in proportion to those of *Serridentinus productus* (D, E); *S. productus*, however, is clearly distinguished by its relatively abbreviated symphysis and smaller size. (3) *Trobelodon taoensis* (F) exhibits a broad and relatively elongate symphysis and relatively enlarged inferior incisors but which have the same transverse section as that of *Ocalientinus* and of *Serridentinus.* Accordingly all these three animals, *Ocalientinus ojocaliensis*, *Serridentinus productus*, and *Trobelodon taoensis*, may be described as 'prod-tuskers' or 'scaptobelodonts,' the tusks probably functioning in the same way in fairly compact soil. They may in turn be clearly distinguished from *Serbelodon* (Fig. 408), a lateral branch of the Serridentinæ, in which the inferior incisors are of a broad, shovel-tusk type adapted to more moist conditions and softer soil.

[1] *Trilophodon joraki* Frick, 1933, may prove to be a synonym of *T.* (*Megabelodon*) *lulli* Barbour, 1914 (see Fig. 245, p. 297).

[2] (( )) = estimated.

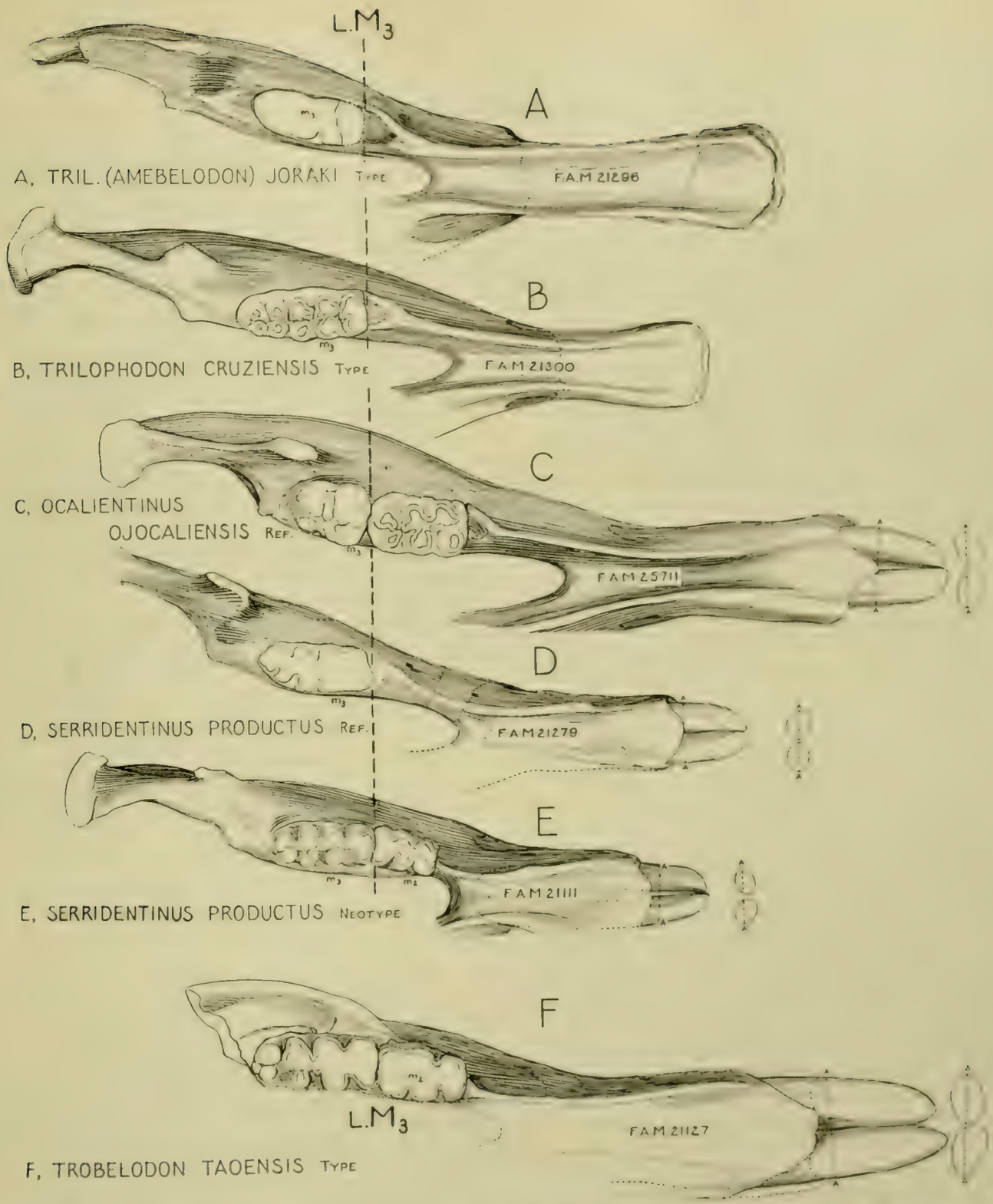


Fig. 281. Frick's Mandibular Types of Trilophodon (A, ?Megabelodon), Ocalientinus, Serridentinus, Trobelodon Drawings after Childs Frick, 1933; generic and specific references in part by Osborn. Uniform reduction to a one-eighth scale

A, B, **Trilophodon, with elongate, flattened symphysis, subfamily Longirostrinæ**

A B, Incisorless mandibles of (A) *Trilophodon joraki* type, (B) *T. cruziensis* type, in the Frick Collection, M_3 of both specimens with $5\frac{1}{2}$ ridge-crests. Compare A, *Trilophodon joraki* type rostrum, with that figured on page 297, figure 245, above, referable either to *Trilophodon joraki* or to *T.* (*Megabelodon*) *lulli*.

C, **Ocalientinus, with very elongate, grooved symphysis, subfamily Serridentinæ**

C, *Ocalientinus ojocaliensis* ref., M_3 with $4\frac{1}{2}$ ridge-crests.

D, E, **Serridentinus, with less elongate symphysis, subfamily Serridentinæ**

D, *Serridentinus productus* ref., M_3 with $4\frac{1}{2}$ ridge-crests.
E, *Serridentinus productus* neotype, M_3 with $4\frac{1}{2}$ ridge-crests.

F, **Trobelodon, with elongate, flattened symphysis, subfamily Serridentinæ**

F, *Trobelodon taoensis* type, M_3 with 4 ridge-crests. Tusks greatly enlarged.

CONTRASTS BETWEEN THE 'UPROOT'- OR 'PROD-TUSKERS' (SCAPTOBELODONTS), THE 'OBLIQUE-TUSKERS' (TRILOPHODON GIGANTEUS); THE 'FLAT-TUSKERS' (PLATYBELODONTS), AND THE 'SHOVEL-TUSKERS' (AMEBELODONTS)

Uprooters.—The adjoining figure (Fig. 282) and other figures referred to in the present chapter illustrate the mandibular and incisor adaptations of *Trilophodon* and *Serridentinus* in which the lower incisors are relatively narrow and elongate, functioning in the digging up of the soil and in the uprooting of plants; in all these animals the mandibles and the tusks may be greatly elongated and narrowed but never greatly broadened. They may be known as the 'uproot'- or 'prod-tuskers' (Scaptobelodonts, from the Greek σκάπτω, to dig, βέλος, dart, and ὀδούς, tooth), in contrast to the 'shovel-tuskers' in which the tusks are greatly broadened while the mandible is relatively shortened and strengthened.

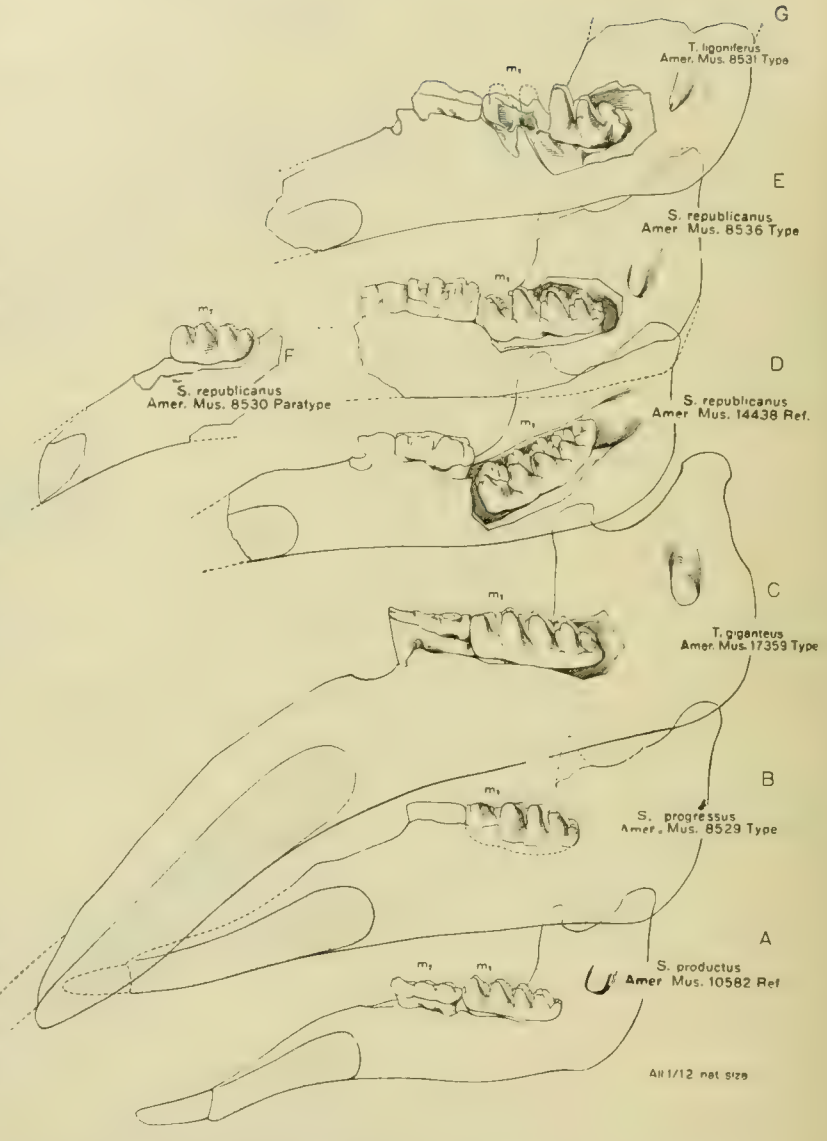
The 'uproot'- or 'prod-tuskers' are shown to divide into a number of specializations: (Fig. 282 A, B) in which the jaw remains nearly horizontal, and (D,E) in which the jaw is progressively elongated and the incisive tusks abbreviated. In the 'oblique-tuskers' (C) the jaw is strongly deflected or decurved and the lower incisive tusks are greatly extended beyond the mandible.

Shovelers.—The discovery and description of *Amebelodon fricki* by Barbour in the year 1927 opened a new epoch in our knowledge of the trilophodonts, namely, of a previously unknown phylum characterized by a remarkable specialization of the lower incisive teeth for *shoveling* function rather than uprooting function observed in the previously known trilophodonts. To this new and extraordinary line of specialization Barbour appropriately applied the generic name *Amebelodon* from the Greek ἀμη, shovel, βέλος, dart, and ὀδούς, tooth. On this most appropriate Greek word *Amebelodon* he established the new family name Amebelodontidæ in 1927, which in 1929, he modified to Amebelodontinæ, signifying the 'shovel-tuskers.'

Meanwhile Borissiak, in the very same summer of 1927, exploring in the Chokrak beds of the Kuban region, north Caucasus, made a parallel and most welcome discovery of a distinct type of 'shovel-tusker' or 'flat-tusker' to which (January, 1928) he applied the generic name *Platybelodon*, derived from the Greek πλατύς, flat, βέλος, dart, and ὀδούς, tooth.

The following summer (July 28, 1928) Roy Chapman Andrews and Walter Granger discovered in the Upper Miocene Tung Gur horizon of the Gobi Desert, Mongolia, a second 'flat-tusker,' subsequently named *Platybelodon grangeri* Osborn, 1931.

It was at first supposed that the 'shovel-tuskers' and the 'flat-tuskers' were closely related, but it was subsequently found that *Amebelodon* had relatively long, narrow shovel tusks, whereas *Platybelodon* had relatively short and extremely broad flat-end tusks. For *Amebelodon* the subfamily Amebelodontinæ Barbour, 1927, 1929, is retained. *Platybelodon* is transferred to the subfamily Platybelodontinæ Borissiak, 1928 (see Chap. X).



(C, G), Oblique-tuskers,' Trilophodon giganteus and T. ligoniferus; (B,A) 'Uproot-tuskers,' Serridentinus and (F,E,D) Ocalientinus

Fig. 282. Comparison of lower jaws in the American Longirostrinæ and Serridentinæ, hyperlongirostral and medilongirostral, internal views, lingual surface of molars. Uniform scale of one-twelfth natural size. M_2 three crested, i.e., trilophodont throughout, except in (F) *Ocalientinus republicanus*, which is four crested.

F, *Ocalientinus republicanus* paratype, Amer. Mus. 8530; M_2 with 4 crests. Republican River basin, Kansas.

G, *Trilophodon ligoniferus* type, Amer. Mus. 8531; M_3 with $4\frac{1}{2}$ to 5 crests. Black Hills, South Dakota.

E, *Ocalientinus republicanus* type, Amer. Muss. 8536; M_3 with $4\frac{1}{3}$ crests. Republican River basin, Kansas.

D, *Ocalientinus republicanus* ref., Amer. Mus. 14438; M_3 with $4\frac{3}{4}$ crests. Springview, Nebraska.

C, *Trilophodon giganteus* type, Amer. Mus. 17359; M_3 with $4\frac{1}{2}$ to 5 crests. Eastview, near Dallas, South Dakota. Example of an 'oblique-tusker.'

B, *Serridentinus progressus* type, Amer. Mus. 8529; M_3 with $4\frac{1}{2}$ crests. Hitchcock County, Nebraska.

A, *Serridentinus productus* ref., Amer. Mus. 10582; M_3 with $4\frac{1}{5}$ crests. Clarendon beds, Texas.

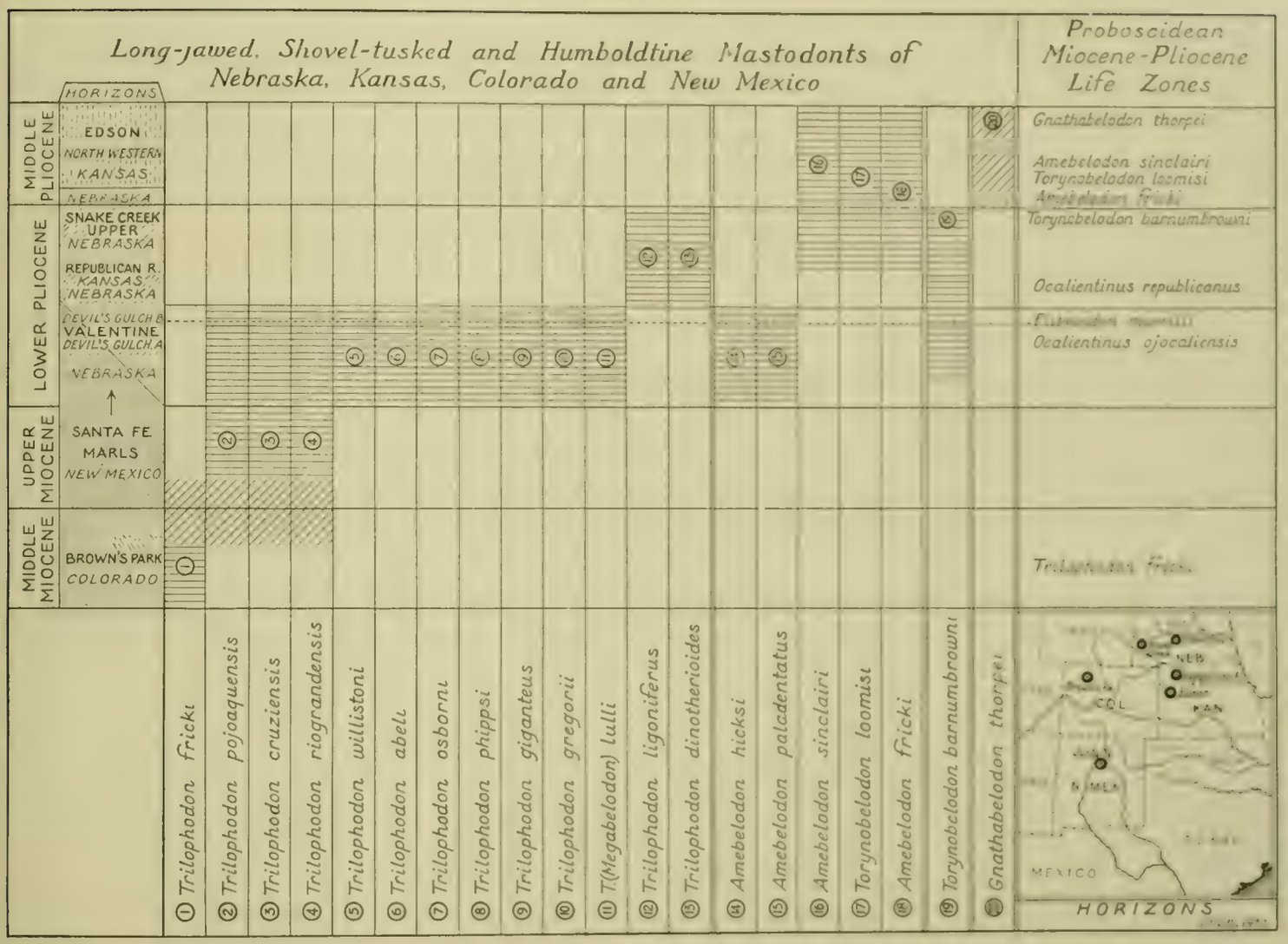


PLATE VII

MIOCENE TO PLIOCENE SUCCESSION OF THE LONGIROSTRINÆ, AMEBELODONTINÆ, PLATYBELODONTINÆ, AND GNATHABELODONTINÆ ALONG THE ANCIENT RIVERS OF THE NORTHERN PLAINS

FOR THE TETRALOPHODONTINÆ AND HUMBOLDTINÆ, SEE PLATE VIII

THIS CHART WAS COMPILED BY OSBORN AND COLBERT FROM VARIOUS SOURCES AND ILLUSTRATES THE DISCOVERIES OF MANY AUTHORS

17. SUMMARY OF THE ORIGIN AND PHYLOGENETIC SUCCESSION OF THE TRILOPHODONTS

The American Trilophodonts are now (1935) known to divide into three[1] adaptations of the incisive teeth. (p. 331, A) the 'uproot'- or 'prod-tuskers,' variants of the typical *Trilophodon*; (p. 331, B) the 'oblique-tuskers,' e.g., *T. dinotherioides, T. ligoniferus, T. giganteus;* (p. 331, C) the 'shovel-tuskers,' e.g., the typical *Amebelodon*.

In the eleven American species of *Trilophodon* and *Amebelodon*, the types of which are herewith described, we must first distinguish the growth stages, namely, 'juvenile,' 'young adult,' 'fully adult,' 'aged,' and 'extremely aged' or 'senescent' types.

Juvenile Types	Young Adult to Adult Types	Aged or Senescent Types
Trilophodon (Genomastodon) willistoni	*Trilophodon (Genomastodon) osborni* *Trilophodon giganteus* *Trilophodon abeli* *Trilophodon pojoaquensis*	*Trilophodon dinotherioides* *Trilophodon ligoniferus* *Trilophodon (Megabelodon) lulli* *Amebelodon (Trilophodon) hicksi* *Amebelodon (Trilophodon) paladentatus* *Amebelodon fricki*
Complete milk dentition in function	Second and third grinders, M^2-M_2, M^3-M_3, in function	Third grinders, M^3-M_3, more or less well worn, in function
Jaws moderately elongated, slightly decurved	Mandibular ramus elongated, horizontal, or slightly decurved	Mandibular rostrum extremely elongated, horizontal, or decurved

Age or Growth Characters. (1) The juvenile jaws with milk dentition (e.g., *Trilophodon willistoni*) are relatively short and slightly decurved. (2) The above comparison proves that the loss of M^2-M_2 is an invariable age or senescent character, and that in extreme old age (e.g., *T. lulli*) the mastication of the food depended solely on the much worn M^3-M_3. (3) The extreme *elongation* of the jaw is also an age character: the longest jaws observed are those of the extremely aged *T. lulli* (Fig. 244) and *Amebelodon fricki* (Fig. 283); they are not deflected. (4) The downward deflection or decurvation of the jaw is *not* an age or growth character; it is a phyletic character

Comparative Measurements of Lower Jaws of Six Species of Trilophodon and of Three Species of Amebelodon	Trilophodon *T. phippsi* Cook, type	*T. phippsi* ref. F:A.M. 22411	*T. fricki* Peterson, type	*T. abeli* Barbour, type	*T. osborni* Barbour, type	*T. (Megabelodon) lulli* Barbour, type	*T. giganteus* Osborn, type	Amebelodon *Amebelodon (Trilophodon) hicksi* Cook, type	*Amebelodon (Trilophodon) paladentatus* Cook, type	*Amebelodon fricki* Barbour, type
Total length of mandible and tusks (tip of tusk to back of condyle)			1292	1359	1522 [1525]		1710 inc. plaster	1420	1482	1970
Total length of mandible without tusk	1486	1220	1134	1156	1346	1504	1560	1050	940	1475
Total length of symphysis	673	400	492	470	483	724	700	460	438	650
Total length of inferior tusks				508						1144
Length of tusks in front of symphysis			132	216	249	242	160 plaster	380	485	455
Depth of jaw under M_3	177	166	153	190		206	220	150	151	222
Sixth molar (M_3), length of	232	197	172	185	196	222	172	199	174	229
Sixth molar (M_3), width of	82	87	73	76	80	89	91	80	79	89
Index: $\frac{\text{Width of molar} \times 100}{\text{Length of molar}}$	35	44	42	41	41	40	53	40	45	39
Fifth molar (M_2), length of	123	100					140e	88		
Fifth molar (M_2), width of	95	80					86	76		

[1]To these has been added a fourth division, known as the tuskless 'spoon-bills,' including *Trilophodon (Megabelodon) lulli* (Fig. 243), *T. phippsi* (Fig. 269), *T. cruziensis* (Fig. 279), *T. joraki* (Fig. 281 A).

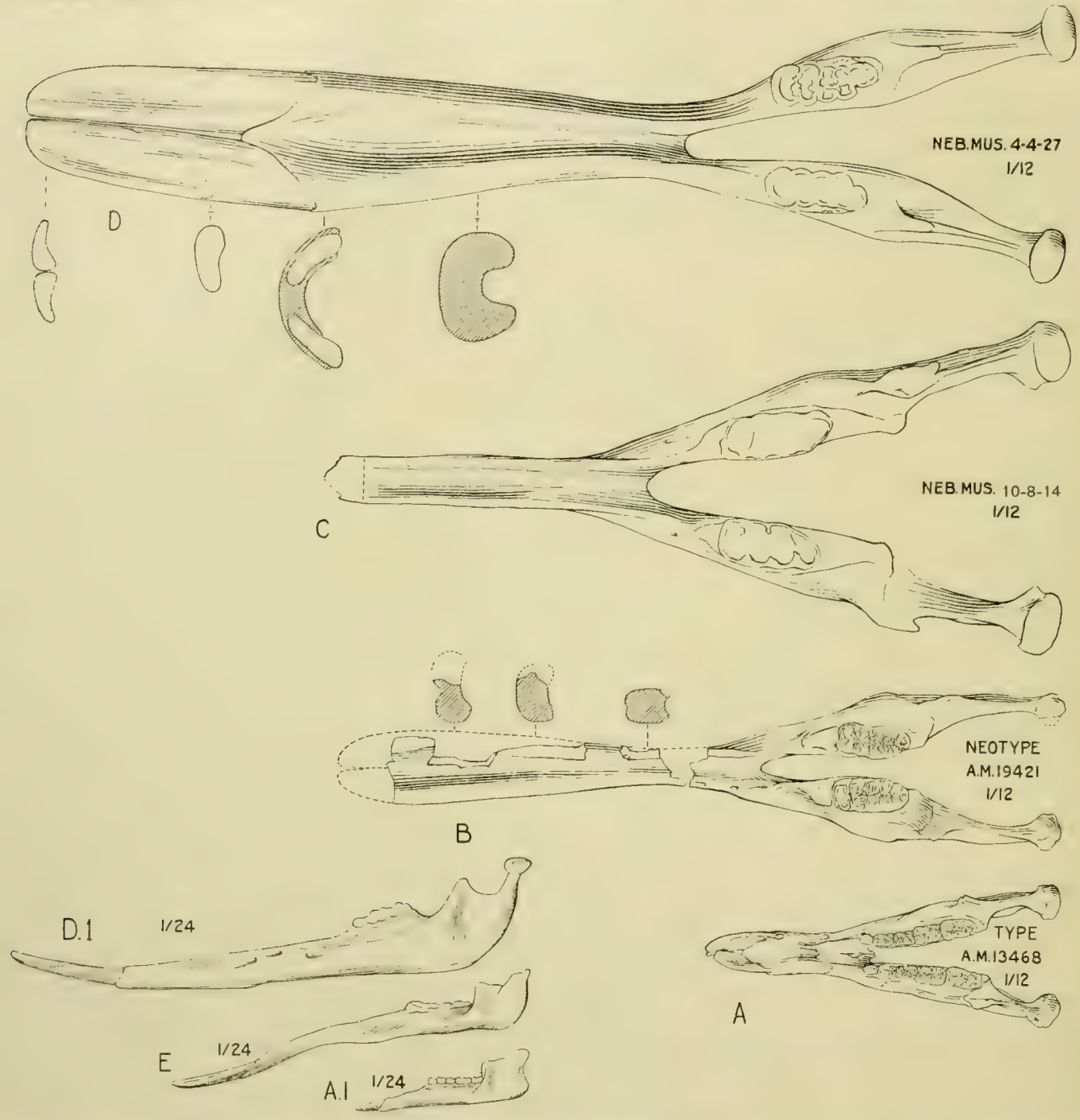


FIG. 283. RESEMBLANCES AND CONTRASTS BETWEEN THE ANCESTRAL OLIGOCENE PHIOMIA (A, A1), THE MIO-PLIOCENE 'UPROOT-TUSKER' TRILOPHODON (B, E), THE PLIOCENE 'SHOVEL-TUSKER' AMEBELODON (D, D1), AND THE TUSKLESS 'SPOON-BILL' TRILOPHODON (MEGABELODON) LULLI (C). TOP VIEWS, ONE-TWELFTH SCALE; LATERAL VIEWS, ONE TWENTY-FOURTH SCALE. DRAWN IN 1928.

D, *Amebelodon fricki* type, Pliocene, Nebraska; in Nebraska Museum; actual length of mandible and shovel-tusks 1970 mm. See corrected figure (Pl. v, pp. 235–236).

D1, *Amebelodon fricki* type. 'Shovel-tusker of Nebraska.

C, *Trilophodon* (*Megabelodon*) *lulli* type, Pliocene, Nebraska; in Nebraska Museum; actual length of tuskless mandible 1504 mm. Tuskless 'Spoon-bill.'

E, *Trilophodon angustidens* of Sansan,[1] after pencil sketch by Charles R. Knight (cf. Fig. 200); in Paris Museum, actual length of mandible and tusks 1950e mm.

B, *Trilophodon chinjiensis* holotype, Lower Chinji, Mio-Pliocene, India.

A, *Phiomia osborni* type, Fluvio-marine beds, Oligocene, Fayûm, Egypt. 'Shovel-tusker.' See corrected figure (Pl. v, pp. 235–236).

A1, *Phiomia osborni* type, primitive 'shovel-tusker' of Africa.

[1] *Trilophodon angustidens* jaws in the Paris Museum, partly restored, redrawn after pencil sketch by Charles R. Knight, one twenty-fourth natural size (cf. Fig. 200 to one-thirtieth scale, also same skull and jaws in Fig. 199 incorrectly restored): the extremely long, slender ramus agrees closely in character and proportions with the American *Trilophodon* jaws here figured, namely, B, C, D.

MUTATIONS (OSBORN, 1926–1930). The 'uproot'- or 'prod'- and 'shovel-tuskers' appear to divide into three series: (A) in which the jaw remains nearly horizontal, (B) in which the jaw is strongly deflected or decurved, and (C) in which the incisive tusks lengthen and broaden into the 'shovel-tusk' adaptation as below.

(A) Jaw slender, nearly horizontal or very slightly decurved; tusks horizontal or directed upwards ('prod-tuskers'):

Trilophodon (Genomastodon) willistoni, juvenile, single trefoils only; M_3 with ?4½ crests.

Trilophodon abeli, young adult, M_3 with 4½ crests; ap. 185 mm., rudiments of double trefoils.

Trilophodon pojoaquensis, young adult, M^3 with 4⅓ crests; ap. 197 mm.

Trilophodon (Genomastodon) osborni, young adult, M_3 with 4½ crests; ap. 196 mm.; rudiments of double trefoils.

(B) Jaw massive, strongly decurved; tusks appressed, directed downwards ('oblique-tuskers'):

Trilophodon fricki, adult, M_3 with 4 ridge-crests; ap. 172 mm. Very primitive.

Trilophodon dinotherioides, adult, M_3 with 4½ to 5 crests, rudiments of double trefoils; ap. 240 mm.

Trilophodon ligoniferus, adult, M_3 with 4½ to 5 crests, rudiment of double trefoil; ap. 245 mm.

Trilophodon giganteus, young adult, M_3 with 4½ to 5 crests, one rudiment of double trefoil; ap. 172 mm.

(C) Jaw elongated, slightly upcurved; tusks elongated, broadened, appressed, alveolar portion concave above ('shovel-tuskers'):

Amebelodon fricki, aged, M_3 with 5½ crests; ap. 229 mm.

Amebelodon sinclairi, tusks only known.

Amebelodon (Trilophodon) hicksi, aged adult, M_3 with 5½ crests; ap. 199 mm.; four rudiments of double trefoils.

Amebelodon (Trilophodon) paladentatus, aged, M_3 with 4 crests; ap. 174 mm.

CHARACTERS (OSBORN, 1926–1930).—The above furnishes a clear key to the characters in which these species resemble or differ from each other. The clearly outstanding progressive characters are: (1) The five and a half ridge-crests observed in *Amebelodon (Trilophodon) hicksi;* (2) the addition of *rudiments of double trefoils*, (a) one such rudiment is observed in *T. giganteus*, (b) three such rudiments are observed in *T. dinotherioides*, and (c) four such rudiments are observed in *A.* (*T.*) *hicksi*. Consequently the species *A.* (*T.*) *hicksi* and *A. fricki* are the most progressive members of the American series and are to be compared with the very progressive five and a half crested form (Fig. 218) observed in the *T. angustidens gaillardi* of Villefranche d'Astarac. (3) By far the most progressive stage is the recently discovered *A. fricki:* (a) in the extreme elongation of the jaw; (b) in the prodigious development of the 'shovel-tusks'; (c) in the corresponding expansion of the symphysis, and (d) in the five and a half ridge-crests in the third inferior molars, M_3.

(A) Slender jaws, rami and relatively short, rodlike tusks nearly horizontal. 'PROD-TUSKERS.'

Trilophodon fricki
Finely preserved rodlike tusks. M_3, ap. 172 mm.; 4 ridge-crests.

Trilophodon abeli
M_3, ap. 185 mm.; 4½ crests, double trefoil rudiments.

Trilophodon pojoaquensis
M^3, single trefoils, rudiments of double trefoils; ap. 197 mm.; 4⅓ crests.

Trilophodon (Genomastodon) osborni
M_3 with 4½ crests; ap. 196 mm.; rudiments of double trefoils.

Trilophodon (Genomastodon) willistoni
Single trefoils.

(B) Massive jaws, rami and inferior tusks appressed and decurved. 'OBLIQUE-TUSKERS.'

Trilophodon dinotherioides
M_3, ap. 240 mm.; 4½ to 5 crests, rudiments of double trefoils.

Trilophodon giganteus
M_3, ap. 172 mm.; 4½ to 5 crests, rudiment of double trefoil.

Trilophodon ligoniferus
M_3, 245 mm.; 4½ to 5 crests, rudiment of double trefoil.

(C) Elongated jaws, slightly upcurved; incisive tusks elongated, broadened, appressed, alveolar portion plano-concave above. 'SHOVEL-TUSKERS.'

Amebelodon fricki
M_3, ap. 229 mm.; 5½ crests, single trefoils.

Amebelodon (Trilophodon) hicksi
M_3, ap. 199 mm.; well-developed double trefoils.

Amebelodon (Trilophodon) paladentatus
M_3, ap. 174 mm.; 4 crests.

ASCENDING PHYLOGENETIC ORDER (OSBORN, 1933–1934).—It has required very close examination and comparison of the above types of trilophodonts to determine the progressive phylogenetic order, to which reference is made at the opening of this chapter. Meanwhile the approximate phylogenetic order corresponding with the ascending geologic order in Miocene and Pliocene times, will be set forth in the charts of the Appendix at the close of the present Volume I.

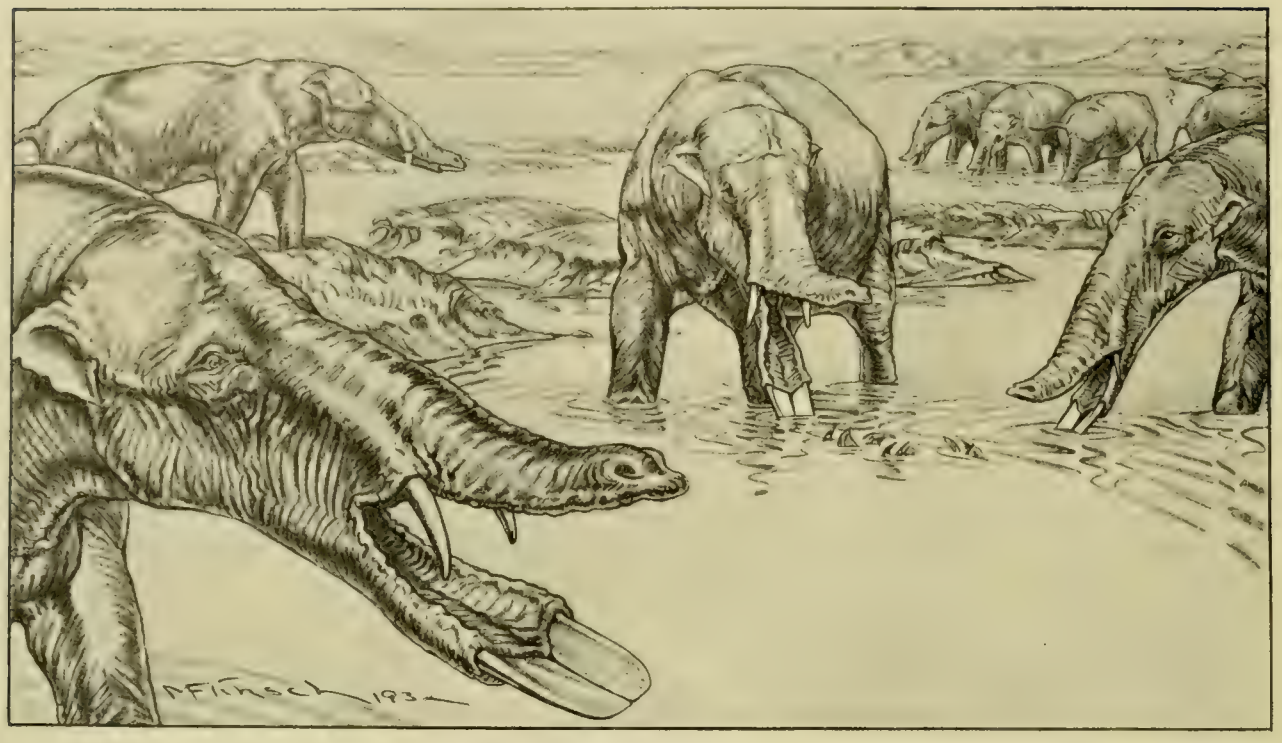


Fig. 284. Restoration (1932) of the 'Shovel-tusker' Amebelodon fricki of Nebraska. By Margret Flinsch, under the direction of Henry Fairfield Osborn

Amebelodon possibly persisted through the Pliocene. The present figures are restored from an adult mandible in the Nebraska State Museum (Neb. Mus. 4-4-27) found near Freedom, Frontier County, Nebraska. Males (lower left and center) one twenty-fourth natural size, male (upper left) one-hundredth natural size, female (right) one sixty-fifth natural size. Compare figure 423, where the estimated shoulder height in the flesh is given as 3047 mm. or 10 ft.

PLATYBELODONTINÆ. 'FLAT-TUSKERS'

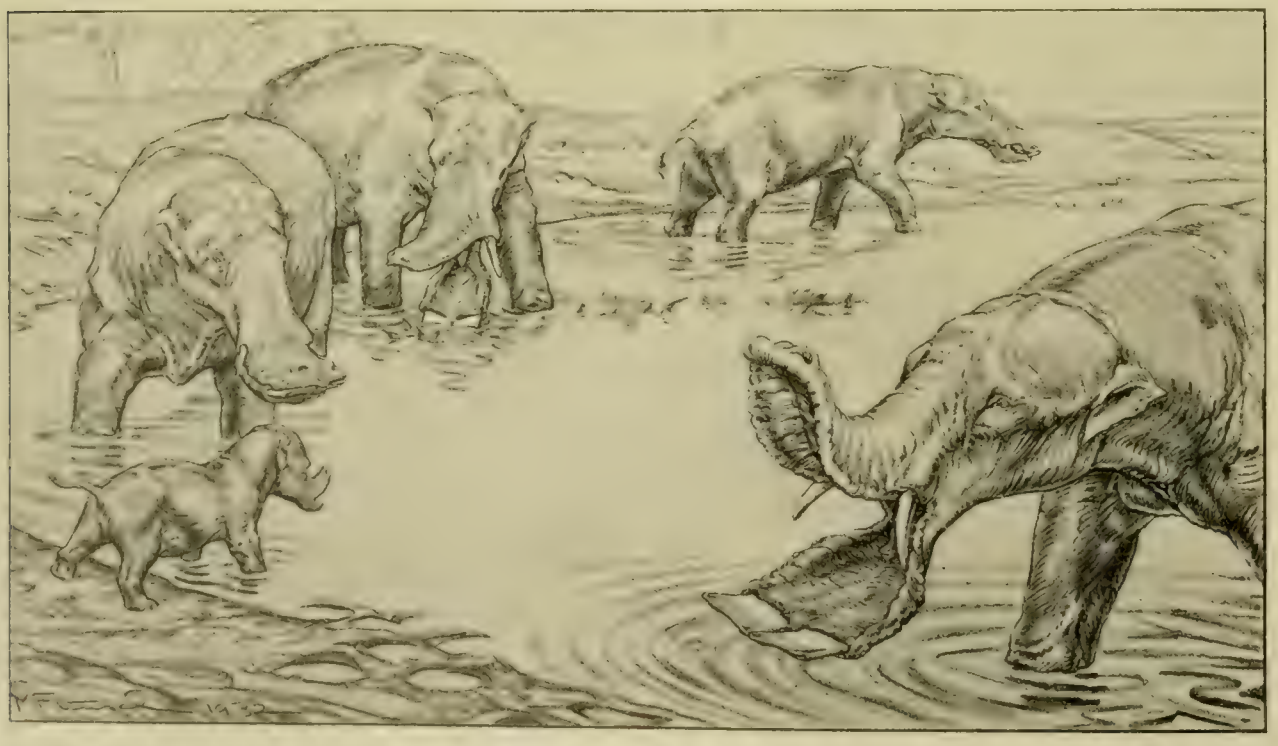


Fig. 285. Restoration (1932) of the 'Flat-tusker' Platybelodon grangeri, Male, Female, and Young. By Margret Flinsch, under the direction of Henry Fairfield Osborn

Male (right) one twenty-fourth natural size. Female and young (lower left) one thirty-fifth natural size. Male (upper left) one-fiftieth natural size. Male (deep center) one ninety-seventh natural size. After remains of fifty individuals collected under the direction of Andrews and Granger by the Third Asiatic Expeditions in the Tung Gur horizon of the Tairum Nor Basin, Mongolia (see Figs. 429–439).

18. DISCOVERY AND DESCRIPTION OF THE 'SHOVEL-TUSKERS' (AMEBELODON, 1927), SUCCESSORS TO PHIOMIA OSBORNI. SEE PLATES V AND VI

The contrasts between the 'shovel-tuskers,' of the new subfamily Amebelodontinæ Barbour, and the 'flat-tuskers,' of the new subfamily Platybelodontinæ Borissiak, simultaneously discovered in the year 1927 in Nebraska and Central Asia respectively, are briefly pointed out above (p. 328), also more fully below.

In the present Section 18 there is set forth in detail the characters of the three[1] different species of Amebelodonts in the chronologic order of their independent discovery by E. H. Barbour of the University of Nebraska, and in Chapter X the characters of the two species of Platybelodonts discovered by A. Borissiak of the Museum of the Academy of Sciences of the Union of Socialist Soviet Republics, also Professor of Geology in the Leningrad Institute of Mines, and by Roy Chapman Andrews and Walter Granger of the Central Asiatic Expeditions of The American Museum of Natural History.

It is especially interesting to record the independent but closely parallel conclusions of Barbour and of Borissiak as to the functional adaptations of the two lower incisive tusks for analogous but slightly differentiated feeding habits and the concomitant nasolabial modifications of the proboscis. To make this clear, lifelike restorations by the present author are reproduced in full, in contrast with each other, also with the nasolabial and mandibular adaptations of the 'uproot-tuskers,' namely, progressive species of *Trilophodon* of the subfamily Longirostrinæ and of *Serridentinus* of the subfamily Serridentinæ, as seen in their respective chapters.

As to the latter, the fortunate discovery of the new species of 'uproot-tusker' *Serridentinus gobiensis*, in Upper Miocene beds of the same geologic age as those which yielded *Platybelodon grangeri*, proves that under Osborn's principle of 'local adaptive radiation' the flat-tuskers and the uproot-tuskers lived and flourished in contiguous regions and contiguous habitats, seeking the bulbs or roots of divers species of water and of terrestrial plants.

Family: BUNOMASTODONTIDÆ Osborn, 1921

Subfamily: AMEBELODONTINÆ Barbour, 1929

Original reference: Neb. State Mus., Bull. 15, Vol. I, December, 1929, p. 139 (Barbour, 1929.2).

Subfamily Characters.—(1) Cranium and rostrum uniformly abbreviated and reduced in size. (2) Lower jaws elongated (longirostral), moderately expanded towards the extremities (*Amebelodon*), greatly expanded towards the extremities with hollow superior symphyseal cavities (*Platybelodon*). (3) Superior incisive tusks reduced in size, downcurved, outcurved, with persistent outer enamel band; greatly reduced in females. (4) Inferior incisive tusks without enamel band, with internal dentinal laminæ; greatly elongated, somewhat broadened; closely appressed in the median line (*Amebelodon*); greatly broadened and abbreviated, transversely truncated (*Platybelodon*). (5) Grinding teeth brachyodont with single trefoils, intermediate grinders trilophodont; in old age reduced to a single pair above and below. Central conules derived from *Phiomia*.

The above definition includes the 'flat-tusker' *Platybelodon*, now (1935) known to be distinct from the 'shovel-tusker' *Amebelodon*.

This subfamily of longirostral (*Amebelodon*) trilophodont mastodonts differs from the typical Longirostrinæ (represented by species of *Trilophodon* in which the incisive tusks are hollow) in the high degree of specialization for the shoveling, digging, or dredging functions of the inferior tusks, reinforced by internal dentinal laminæ.

The presence in the inferior tusks of dentinal laminæ in *Amebelodon* precludes its analogy to *Platybelodon*; also because of the differences in molar structure, they are separable into two subfamilies:

Amebelodon Barbour, with relatively long and slender rostrum; incisors elongate, rounded at extremities, hollow, with progressive dentinal laminæ (see Pl. V). Subfamily Amebelodontinæ Barbour, 1929, an offshoot of *Phiomia* stock (cf. *Phiomia osborni*).

[1] *Torynobelodon loomisi* Barbour, at first considered by Osborn as belonging to the Amebelodontinæ, is described in the present Section 18, although it should appear in Chapter X, under the Platybelodontinæ (p. 459 *et seq.*), as recent study by the present author proves *Torynobelodon* to be a valid genus.

Platybelodon Borissiak, with short and extremely broadened rostrum; incisors progressively broadening, sharpened at extremities, solid with closely compacted rod-cones (see Figs. 296 and 430). Subfamily Platybelodontinae Bor., 1928, an offshoot of the *Serridentinus* stock (Chap. X).

Osborn, 1935: For direct descent of *Amebelodon fricki* from *Phiomia osborni*, see Pl. v, pp. 235-236. See also Appendix of the present Volume I for remarkable changes of proportion in *Phiomia* and *Amebelodon* and dominance of the inferior incisive tusks. *Amebelodon* is now (1935) known to include the following four species:

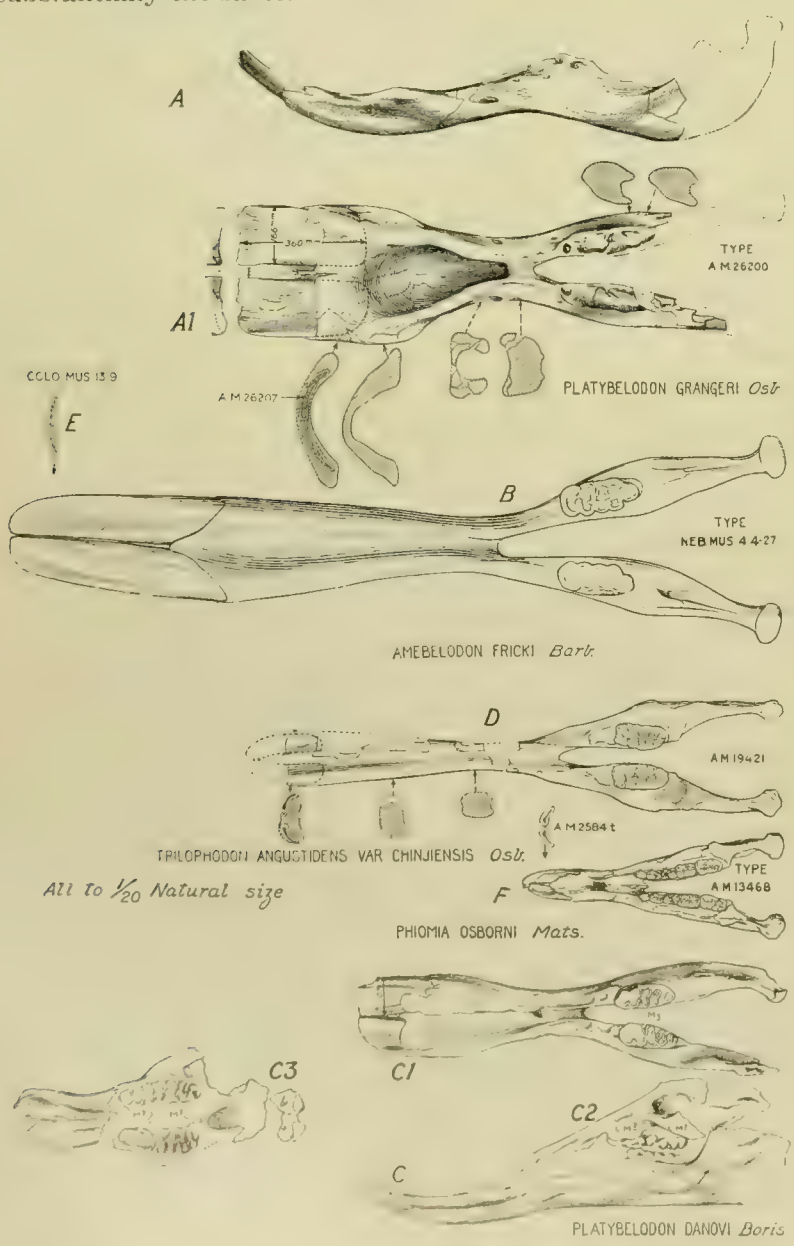
Amebelodon fricki Barbour, 1927, Freedom, Frontier County, Nebraska (pp. 335-337).

Amebelodon sinclairi Barbour, 1930, Freedom, Frontier County, Nebraska (pp. 337, 338).

Amebelodon (*Trilophodon*) *hicksi* Cook, 1922, Wray, Yuma County, Colorado (pp. 307-309).

Amebelodon (*Trilophodon*) *paladentatus* Cook, 1922, Wray, Yuma County, Colorado (pp. 309-311).

The comparative diagram (Fig. 286) demonstrates that the postsymphyseal portions of the jaw and grinding teeth undergo little progressive evolution except in size; it is the anterior symphyseal and rostral region of the amebelodont shovel-tuskers that undergoes such an extraordinary specialization, while the grinding teeth remain substantially the same.



G, G1

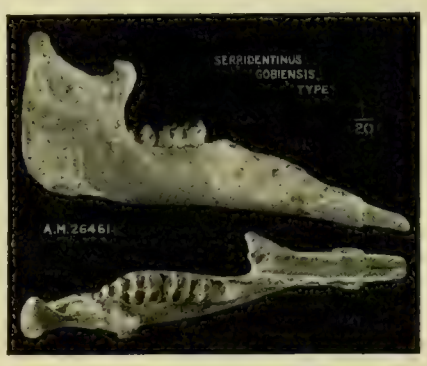


FIG. 286. CONTRASTS BETWEEN THE 'FLAT-TUSKER' PLATYBELODON (A, A1, C–C3), THE 'SHOVEL-TUSKER' AMEBELODON (B, E), AND THE 'UPROOT-TUSKERS' TRILOPHODON CHINJIENSIS (D) AND SERRIDENTINUS GOBIENSIS (G, G1)—OF MIO-PLIOCENE AGE. (F) THE PROBABLE ANCESTRAL OLIGOCENE PHIOMIA OSBORNI.

All figures one-twentieth natural size

A, A1, *Platybelodon grangeri* Osborn, type (Amer. Mus. 26200). Lateral aspect and superior aspect with sections of the rostrum and mandible at six points indicated. 'Flat-tusker.'

B, *Amebelodon fricki* Barbour, type (Neb. Mus. 4–4–27), superior aspect of lower incisors and jaw. 'Shovel-tusker.'

E, Actual section of terminal region of incisive tusk of *Platybelodon* sp. (Colo. Mus. 1319).

C–C3, *Platybelodon danovi* Borissiak, type (Leningrad Mus.), Chokrak beds, Upper Miocene, north Caucasus. Left lateral view of skull and jaws, palatal view, and superior view of mandible.

D, *Trilophodon chinjiensis* Pilgrim-Osborn. Holotype (Amer. Mus. 19421), Chinji horizon, Mio-Pliocene, with sections of hollow lower incisors at three points indicated. 'Prod-tusker.'

F, *Phiomia osborni* Matsumoto, type (Amer. Mus. 13468), Lower Oligocene Fluvio-marine of the Fayûm, Egypt. Ancestral 'shovel-tusker.'

Section of right lower second incisor of *Phiomia osborni* ref. (Amer. Mus. 2584t), from the Oligocene of the Fayûm, Egypt.

G, G1, *Serridentinus gobiensis* Osborn and Granger, type (Amer. Mus. 26461), Upper Miocene, *Platybelodon grangeri* life zone, eastern Mongolia.

Genus: **AMEBELODON** Barbour, 1927

Original reference: Neb. State Mus., Bull. 13, Vol. I, June, 1927, pp. 131–134 (Barbour, 1927.1).
Genotypic species: *Amebelodon fricki* Barbour, 1927.

Generic Characters.—(Barbour, 1927) Mandible expanded, trough-like; broad, flat tusks adapted to shoveling soft sand or perhaps mud; mandible narrowest and weakest at point of greatest stress, near the rami; molars large, doubly trefoiled, inferior molars with five grinding ridges. Tusks extremely elongate (1144 mm.) with concentric dentinal laminæ. Molars with central conules.

Amebelodon fricki Barbour, 1927

Figures 283, 284, 286, 293, 295, 296

From near Freedom, Frontier County, Nebraska. Middle Pliocene.

Amebelodon fricki Barbour, 1927. "Preliminary Notice of a New Proboscidean Amebelodon fricki, gen. et sp. nov." Neb. State Mus., Bull. 13, Vol. I, June, 1927, pp. 131–134. Type.—A fully adult mandible with inferior tusks and five ridge-crested right and left third inferior molars, one rib, and one digital bone. Neb. Mus. 4–4–27, Morrill Coll. Procured April 4, 1927. Horizon and Locality.—A. S. Keith's farm, near Freedom, Frontier County, Nebraska. Formation regarded as of "late Pliocene or possibly early Pleistocene age" (*op. cit.*, p. 133). Columbian mammoth [*Parelephas*] of common occurrence (five individuals); *Teleoceras* and progressive equine molar teeth collected. Type Figure.—*Op. cit.*, figs. 89, 90, 91.

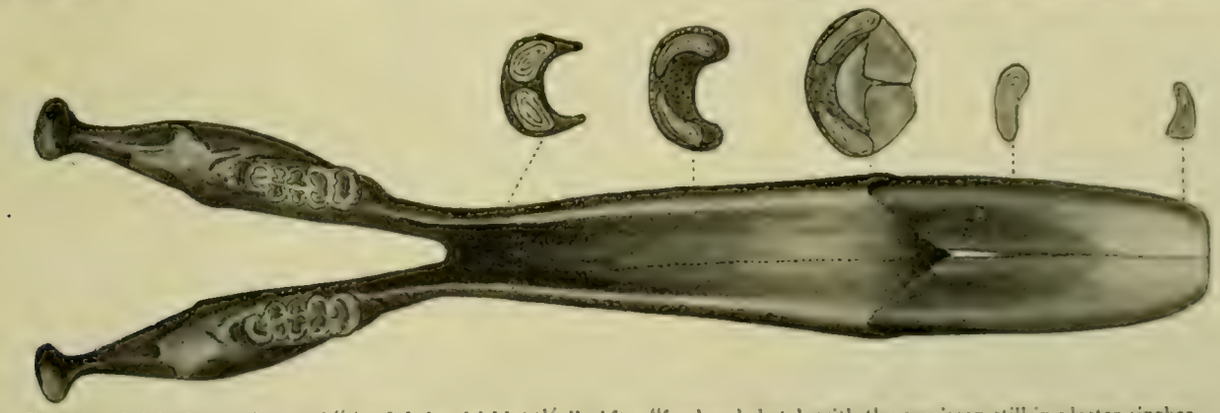


Fig. 287. Original type figure of "*Amebelodon fricki*, ×1/13." After "freehand sketch with the specimen still in plaster cinches. . . . It may be three or four inches too long." Sections 1 to 5 show the full length of the tusks. After Barbour, 1927, fig. 89.

Type Description.—(Cf. Barbour, 1927, pp. 131–134): . . . "the new longirostral mastodon under discussion was a shovel-tusker. We are naming it Amebelodon fricki, in recognition of Professor Childs Frick. A family, the Amebelodontidæ, should be established. The group of broad-tusked proboscideans, dating from Phiomia osborni, may be conveniently designated the shovel-tuskers or the amebelodonts." Mandible expanded, trough-like; broad, flat tusks adapted to shoveling soft sand or perhaps mud; the broadened tusks and flared mandible may have functioned in some way as a shovel, as the tusks seem to have formed a great shovel and the mandible a great trough; mandible narrowest and weakest at point of greatest stress, near the rami, where it is still further weakened by the expansion at the roots of the tusks and by the three vascular foramina (see Fig. 89, section 5 [=Fig. 287 of present Memoir]). The type is essentially perfect. Tusks with the whiteness and density, as well as the decussating lines of ivory. Molars large, 9×3½ in., each with five broad grinding ridges distinctly trefoiled; from external cingulum rise many short, blunt cones. The excessive development of the mandible supports the conception that the upper tusks may have been dwarfed or possibly aborted.

SECOND AND THIRD DESCRIPTIONS BY BARBOUR

"The Mandibular Tusks of Amebelodon fricki," Neb. State Mus., Bull. 14, Vol. I, Dec. 20, 1929, pp. 135–138, fig. 92 (Barbour, 1929.1), also "The Mandible of Amebelodon fricki," Neb. State Mus., Bull. 15, Vol. I, December, 1929, pp. 139–146, figs. 93–97 (Barbour, 1929.2).

Barbour (1929.1, pp. 135, 136) after complete examination and reconstruction of the mandibular tusks: "The tusks, which are immoderately developed, are 5½ inches (140 mm.) wide and 45 inches (1144 mm.) long, and at the bases the inner and outer borders are so folded together as to make in either tusk a deep narrow groove, occupied by a thin pendant plate of bone 12 inches long, 3 inches deep, and ½ inch thick. The tusks are solid for 31 inches back of the tips, the total pulp cavity being 14 inches (356 mm.) long. The alveoli in this mandible are nearly as large as one's head, and casts of them resemble, in size and shape, adult human cerebral hemispheres."

"With the material at hand, it is already apparent that there are two very distinct types of amebelodonts, namely a kind [*Amebelodon*] with long, straight tusks and jaws, and another [*Torynobelodon*] with short, curved tusks and curved jaws. The latter are nature's first dredges, and we are naming them the 'dredge-tuskers.' The name applies to the dredge-like shape, and seems descriptive even though it may subsequently develop that the shovel-tuskers did not shovel, and that the dredge-tuskers did not dredge."

"There was a notable flattening of the mandibular tusks of

Phiomia osborni which is to be counted the precursor of the longirostral mastodons while Mœritherium is the supposed progenitor of the other proboscideans. On the one hand Phiomia gave rise to a great race of long-jawed mastodonts, which flourished and then declined, including Serridentinus, Dibelodon, the Trilophodonts, the Tetralophodonts, the Amebelodonts and Dredge-tuskers."

Barbour (1929.2) with revised measurements and new conjectural restoration of the head of Amebelodon fricki. After a very full discussion of the probable origin, evolution, descent from *Phiomia osborni*, and shovel-tusk adaptations of the Amebelodonts (*op. cit.*, 1929.2, pp. 139–144), the subfamily term AMEBELODONTINÆ replaces the family term Amebelodontidæ.

"The mandibular tusks of Amebelodon are huge in comparison with those of other tetrabelodons, the length being 45 inches (1144 mm.), and the width 5½ inches (140 mm.). The pulp cavities of the tusks seem to have been unduly short, but 14 inches (356 mm.), tapering abruptly. At the base of each, the inner and the outer borders are so folded together as to make a deep groove, which is occupied by a pendant strip of bone about a foot long, three inches deep, and a half inch thick. Amebelodont tusks are so immoderately developed that they are very unlike those of other four-tuskers, of which average mandibular tusks are about one inch to an inch and three-fourths wide, and fifteen to eighteen inches long. . . . From the material already at hand it is plain that there are two very distinct types of amebelodonts, namely one group with straight, long tusks and straight jaws, another group with relatively short, curved tusks and curved jaws, which group we have already designated the dredge-tuskers, to be described in forthcoming papers. It seems a safe prediction that the next few years cannot fail to reveal a rich, interesting, and varied amebelodont fauna."

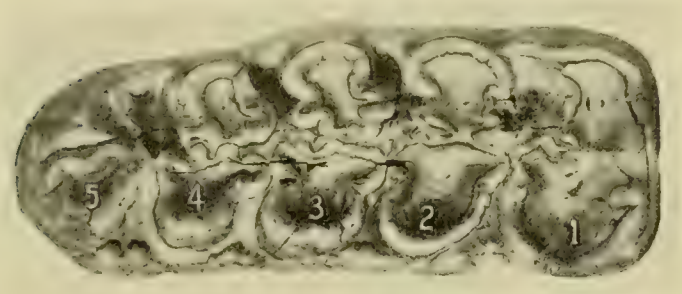


Fig. 288. Type right lower molar, r.M_3, crown view, of *Amebelodon fricki*, "showing five grinding ridges, with trefoiled patterns. Length 9 inches (229 mm.); width 3½ inches (89 mm.). Very low-crowned." Compare Barbour, 1929.2, fig. 95.

Fig. 289. Third lower molar, l.M_3 of *Amebelodon fricki*, one-third natural size. Greatest length 230 mm. (9 in.), width 93 mm. (3⅝ in.). The cement is indicated by stippling. After Barbour, 1927, fig. 90.

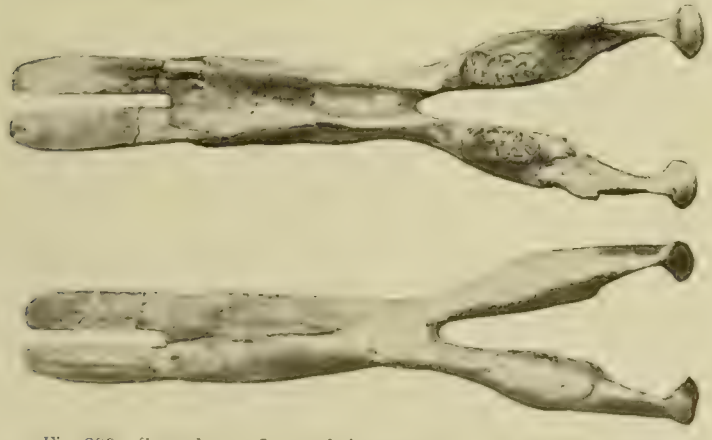


Fig. 290. Second type figure of the mandible of *Amebelodon fricki*. "In life the tusks met on the median line," as shown in the original type figure 287. In the type they "are thrown apart apparently by a sun crack in the bone." (a) Superior aspect. (b) "Same from below, showing a large sun crack." After Barbour, 1929.2, fig. 94.

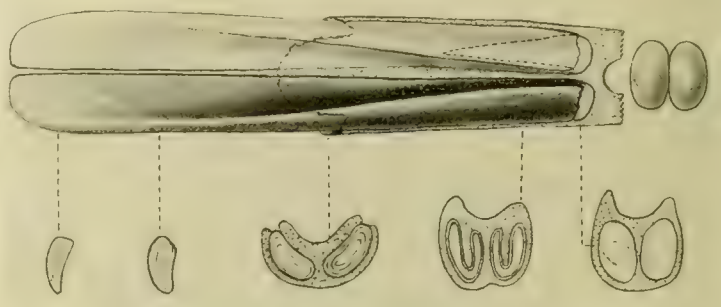


Fig. 291. Brush drawing of type mandibular tusks of *Amebelodon fricki* with surrounding bone indicated by stippling. "Width of each alveolus 5½ inches (140 mm.); height 6½ inches (165 mm.). The dotted lines at the base of the right tusk indicate the size and shape of the pulp cavity. Length of mandibular tusk 45 inches (1144 mm.); width 5½ inches (140 mm.). A—Section at the tip, width 4½ inches (114 mm.); thickness 1¾ inches (44 mm.). B—Section, width 5½ inches (140 mm.); thickness 2 inches (51 mm.). C—Section, width 10½ inches (267 mm.); depth 6 inches (152 mm.). D—Section, width 8 inches (204 mm.); depth 7¼ inches (184 mm.). E—Section, width 7¾ inches (198 mm.); depth 8¾ inches (223 mm.). Length of the pulp cavity 14 inches (356 mm.). Type specimen No. 4–4–27; collections of Hon. Charles H. Morrill in the Nebraska State Museum, the University of Nebraska, Lincoln." After Barbour, 1929.1, fig. 92. Osborn, 1935: Compare Pl. v, pp. 235-236, for dentinal laminæ.

CORRECTED MEASUREMENTS TO 1929

Total length of mandible and tusks	1970 mm.	(approx. 2 m., 6 ft. 5½ in.)
Total length of mandible without tusks	1475	4 ft. 10
Breadth across mandibular condyles	508	20
Breadth across coronoids	457	18
Transverse diameter of condyle	140	5½
Greatest thickness of mandibular ramus	147	5¾
Depth of mandible at tip	165	6½
Depth in front of molar 3	222	8¾
Depth from coronoid to angle	356	14
Third molar:		
Length	229	9
Breadth	89	3½
Height	25–32	1–1¼

Fig. 292. "A pencil sketch showing a conjectural restoration of Amebelodon fricki in its supposed habitat feeding upon aquatic plants. In their life habits they may have been like other longirostral mastodonts, the jaw and tusks being simply extreme developments." After Barbour, 1929.2, fig. 97. Compare Osborn-Flinsch, Fig. 284, p. 332.

Fig. 293

Revised Restoration of Amebelodon fricki

Fig. 293. "A charcoal sketch showing a conjectural restoration of the head of Amebelodon fricki. Total length of the mandible, 6 feet, 5½ inches. Total length from the base of the skull to the tips of the mandibular tusks estimated to have been between 7 and 8 feet." After Barbour, 1929.2, fig. 96.

Amebelodon sinclairi Barbour, 1930

Figure 294

Freedom, Frontier County, Nebraska. Middle Pliocene.

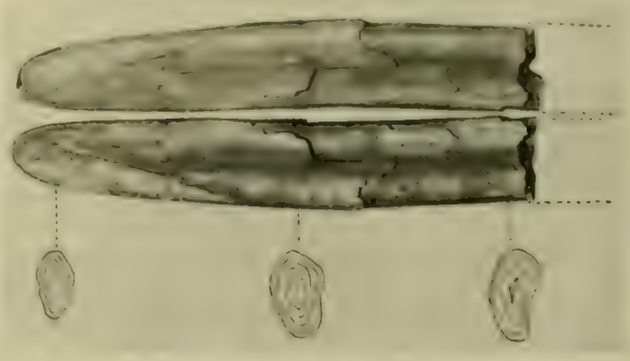
Two and a half years after his description of *Amebelodon fricki*, Barbour described a second species of this interesting genus, naming it *Amebelodon sinclairi* "in recognition of Dr. Wm. J. Sinclair, who has made extensive explorations in the Tertiary of Nebraska." In comparison with *A. fricki* the species is distinguished in the type mandibular tusk as much shorter, relatively more robust, the inner border thicker, and the median borders not contiguous. The original type description rests solely upon the inferior incisive tusk.

Amebelodon sinclairi Barbour, 1930. "Amebelodon sinclairi sp. nov.," Neb. State Mus., Bull. 17, Vol. I, January, 1930, pp. 155–158, text fig. 101. Type.—Mandibular tusk of the right side (Neb. Mus. 1–17–7–28). Horizon and Locality.—(*Op. cit.*, Barbour, 1930, p. 155) : "The specimen under consideration is a mandibular tusk found on the farm of Mr. A. S. Keith, Freedom, Frontier County, Nebraska, on the Morrill Geological Expedition of 1928, and is numbered 1–17–7–28, S. & L., . . . the University of Nebraska." Type Figure.—*Op. cit.*, Barbour, 1930, fig. 101.

Type Description.—(*Op. cit.*, Barbour, 1930, pp. 155–158): "The tusk under consideration is relatively broad and flat and was about twenty-eight inches [712 mm.] in length. Though plainly a related form, it is not flattened at the tip, or distal end, like the tusk of Amebelodon fricki."

"The inner and outer borders are about parallel, with a valley between on the upper side. The tip of the tusk is worn, possibly by digging and shovelling in the same manner as the tusk of Amebelodon fricki, providing they used these tusks for that purpose."

"The mandibular tusk of Amebelodon sinclairi is much shorter and relatively more robust, the inner border is the thicker as in A. fricki. The tusk of A. fricki is essentially straight, or with a long radius of curvature, while in A. sinclairi the curvature is noticeable, the radius being about 5 feet (1525 mm.). . . . The tips of the tusks in A. fricki, for about a foot in length, are plainly worn as may be seen in Fig. 89, Bulletin 13. The tusks of A. sinclairi show considerable wear in the same place. The tusks of A. fricki, where they meet on the middle line, are ground and rubbed flat. Not so those of A. sinclairi, which apparently did not touch."



Type of Amebelodon sinclairi

Fig. 294. "The major portion, ⅔, of the right mandibular tusk of Amebelodon sinclairi, with the same reversed to complete the pair. The left tusk is sectioned, and is in parallel position with, and for comparison with the tusk of Amebelodon fricki. Specimen No. 1–17–7–28, S. & L., Freedom, Frontier County, Nebraska. Section a. Width of tusk at tip 2⅝ inches (67 mm.); greatest thickness at inner border 1½ inches (38 mm.). Section b. Width of tusk 3½ inches (89 mm.); greatest thickness 2 inches (51 mm.). Section c. Width of tusk 3½ inches (89 mm.); greatest thickness 2 inches (51 mm.). Palaeontological Collection of Hon. Charles H. Morrill, the Nebraska State Museum." After Barbour, 1930, fig. 101. One-seventh natural size.

MEASUREMENTS

Amebelodon fricki:

Length of tusk, 45 inches (1144 mm.); width, 5½ inches (140 mm.); greatest thickness, 2¾ inches (69 mm.).

Amebelodon sinclairi:

Length of tusk calculated, 28 inches (712 mm.); width, 3½ inches (89 mm.); greatest thickness, 2 inches (51 mm.).

"The pulp cavity was 10 inches (254 mm.) long, and ends 18 inches from the tip, while in Amebelodon fricki, it is short and ends 31 inches from the tip. Its radius of curvature is about 60 inches. Amebelodon sinclairi, like Amebelodon fricki, belongs to the shovel-tuskers, while Torynobelodon loomisi, with its broad, sharply curved tusks, belongs to the dredge-tuskers."

Fig. 295. "Imaginative sketch of *Amebelodon* showing the great protruding shovel-like mandible, which may have been used to drag out aquatic plants or to dig in sand and soft soil." After Barbour, 1927, fig. 91. Published June 15, 1927.

SUBFAMILY: PLATYBELODONTINÆ Borissiak, 1928

GENUS: TORYNOBELODON Barbour, 1929

Genotypic species: *Torynobelodon loomisi* Barbour, 1929.

See *Paraplatybelodon* Frick, 1933, p. 592.

The genus *Torynobelodon* Barbour, a 'dredge-tusker' with dentinal rod-cones, is now (1935) recognized as an American relative of the genus *Platybelodon* Borissiak of Central Mongolia, fully described on page 459 *et seq.*

Torynobelodon loomisi[1] Barbour, 1929

Figures 296–298

From Sand Canyon, just east of Indian Hill, two and one-half miles southwest of Republican City, Harlan County, Nebraska. Middle Pliocene.

Torynobelodon loomisi Barbour, 1929. "Torynobelodon loomisi, gen. et sp. nov.," Neb. State Mus., Bull. 16, Vol. I, December, 1929, pp. 147–153 (Barbour, 1929.3).

DISCOVERY.—(Barbour, *op. cit.*, p. 147): "In the field season of 1928, two additional species were found which are represented by mandibular tusks. One of these is a tip of a large and unique tusk, numbered 2–3–9–28, S. and L., the collectors being Bertrand Schultz and John LeMar, both of the class of 1931, the University of Nebraska."

HORIZON AND LOCALITY.—"This unusual specimen was found in Sand Canyon, just east of Indian Hill, two and one-half miles southwest of Republican City, Harlan County, Nebraska," Middle Pliocene.

TYPE AND TYPE FIGURE.—Tip of left mandibular tusk. Neb. Mus. 2–3–9–28. The Palæontological Collection of Hon. Charles H. Morrill. Barbour, *op. cit.*, 1929.3, figs. 98, 99, 100.

TYPE DESCRIPTION.—(Barbour, *op. cit.*, pp. 147–150): "Influenced by the coarse ladle-shaped mandible, we have named this new form Torynobelodon loomisi, in recognition of Dr. Fred A. Loomis, who has spent many field seasons in exploring the Tertiary series of Nebraska. . . . The mandibular tusk of A. loomisi is roughly, like that of a giant rodent, broad, flat, chisel-like, and curved, with a radius of two feet. It is concaved above and below throughout its length, hence it has thickened inner and outer borders. The inner border is the thicker of the two. The tip of the tusk is worn to a sharp, thin, chisel-like edge. It is assumed that the wear came about by the actual shovelling, or rather scooping, of muds, sands, and soft earths in the animal's quest for food. If so, herein is realized nature's original dredge, and this group is best designated by the term, dredge-tuskers. In the name [*Torynobelodon*] is implied the character, shape, and possible use of the mandible and strange tusks. The mandible and up-curved tusks could have functioned quite like a dredge. They are to be compared with those of the shovel-tuskers which may have functioned much more like a blunt spade or shovel. The former could plainly dredge or scoop up more material than the latter, and the presumption is that the two kinds of elephants, though fairly similar, had somewhat different life habits. From the material already at hand, it is plain that there are two very distinct groups of amebelodonts, namely the shovel-tuskers with straight tusks, such as Amebelodon fricki and others to be described in Bulletin 17, and the dredge-tuskers, with curved tusks, such as A. loomisi. The differences between the dredge-tuskers and the shovel-tuskers seem more than specific and must be interpreted as generic. Such differences can scarcely be ascribed to variations due to age and sex. . . . The spoon shape may have aided the creature, as well, in collecting seed heads from grasses and wild cereals. The broad, short, curved tusks gave a spoon-shape or dredge-shape to the mandible, suggesting its possible use as an actual dredge. This strangely shaped mandible must rank with the remarkable and unaccountable structures."

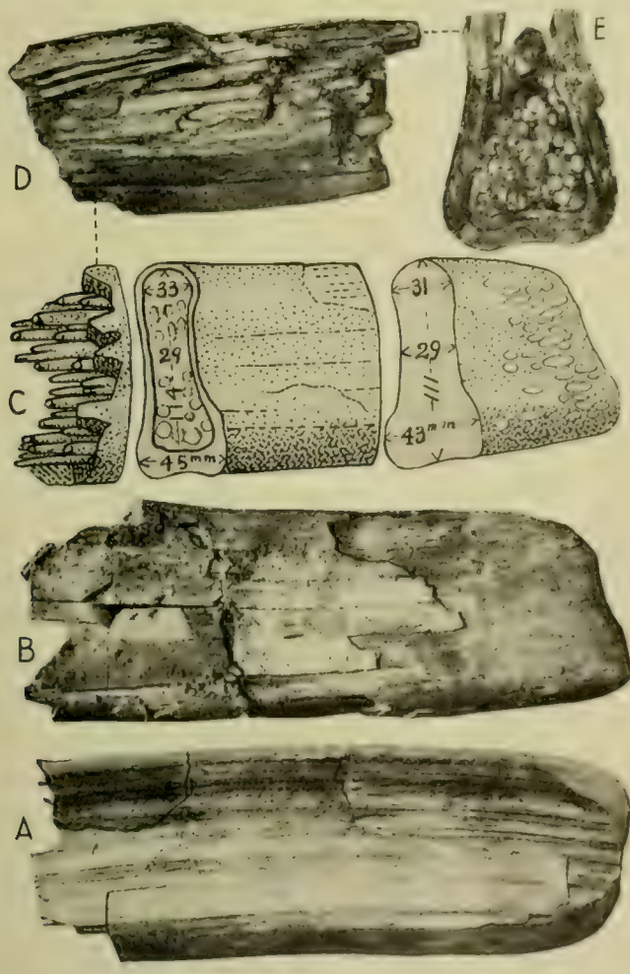
DENTINAL ROD-CONES.—"The worn surface of the tusk as seen in the accompanying cuts, is covered with ellipses, or the outlines of cones cut in oblique sections, and the cones themselves are to be seen at the fractured portions. With the exception of a periphery of decussated ivory, the entire tusk consists of long, slim cones, some of them branching and many intimately intergrown with the concentric ivory plates, as is partly shown in the accompanying illustrations. Some of the cones are 12 inches in length and about ¼ to an occasional ½ inch in diameter at the larger end, as may be seen in Figure 98, c, d, and e, and are similar to the cones seen in many mammoth teeth. The surfaces of the cones show wavy

[1]See *Torynobelodon barnumbrowni* (p. 470)

corrugations, such as are common to the cones of proboscidean teeth, and they seem to be structural rather than induced, or secondary, and are at present problematical. They are so like the bundle of unworn cones commonly seen at the heel of molar teeth that the writer at first sight wondered, too impulsively, if by any chance this tusk could be a modified incisiform molar."

Barbour (*op. cit.*, pp. 149, 151, and 152) accompanies his excellent type description by a type figure (Fig. 98—our Fig. 296), and by a conjectural restoration of the mandible (Fig. 99—Fig. 297 of the present Memoir) "based upon the dimensions and curvature of the mandibular tusks. The flared and ladle-shaped mandible ranks with the rare and unaccountable structures"; also by a "pencil sketch of a purely conjectural restoration of Torynobelodon loomisi, the dredge-tusked mastodon as he may have appeared in his supposed marshy habitat, dredging for various aquatic plants for food. This may be indulging a fancy, for the flared and spoon-shaped mandible may have been simply a case of excessive development and not a scoop" (Fig. 100—the author's drawing initialed "E.H.B.—4-29"—Fig. 298 of the present Memoir). This is accompanied by his speculation (p. 148) as to the feeding habits of the animal on "coarse reeds, cat-tails, pond lilies, and the like, cutting them off by pressing the trunk against the sharp cutting edges of the tusks and lifting upward, much as cattle graze by pressing their thickened and calloused upper lips against their sharp lower incisors, and by swinging the head, shear off tufts of grass."

Osborn, 1931: The incomplete left mandibular tusk (Fig. 296) constituting the type of *Torynobelodon loomisi*, 4½ in. (114 mm.) in breadth, as compared with approximately the same measurement, 4¼ in. (108 mm.) in *Platybelodon danovi*, or 6½ in. (166 mm.) in *P. grangeri*, left us in some doubt as to whether the type of *T. loomisi* were more closely related to *Amebelodon* or to *Platybelodon*.



TYPE OF TORYNOBELODON LOOMISI

Fig. 296. "a. Tip of the left mandibular tusk of Torynobelodon loomisi, seen from below, showing structure and wear. b. Same, seen from above, showing extensive wear at the tip which is reduced to a wedge and which shows many ellipses. . . . Width of tusk 4¼ inches (114 mm.). c. Same, sectioned with structure and measurements. (Note ellipses at the tip and compare with b.) d. Detail. A longitudinal section showing outer zone of decussated ivory and inner core of cones. e. Cross section showing decussated ivory and core of cones. Specimen No. 2-3-9-28, S. & L. The Palaeontological Collection of Hon. Charles H. Morrill." After Barbour, 1929.3, fig. 98.

Fig. 297. "A pencil sketch showing a purely conjectural restoration of the mandible of Torynobelodon loomisi based upon the dimensions and curvature of the mandibular tusks. The flared and ladle-shaped mandible ranks with the rare and unaccountable structures." After Barbour, 1929.3, fig. 99.

Fig. 298. "A pencil sketch of a purely conjectural restoration of Torynobelodon loomisi, the dredge-tusked mastodon as he may have appeared in his supposed marshy habitat, dredging for various aquatic plants for food. This may be indulging a fancy, for the flared and spoon-shaped mandible may have been simply a case of excessive development and not a scoop." After Barbour, 1929.3, fig. 100.

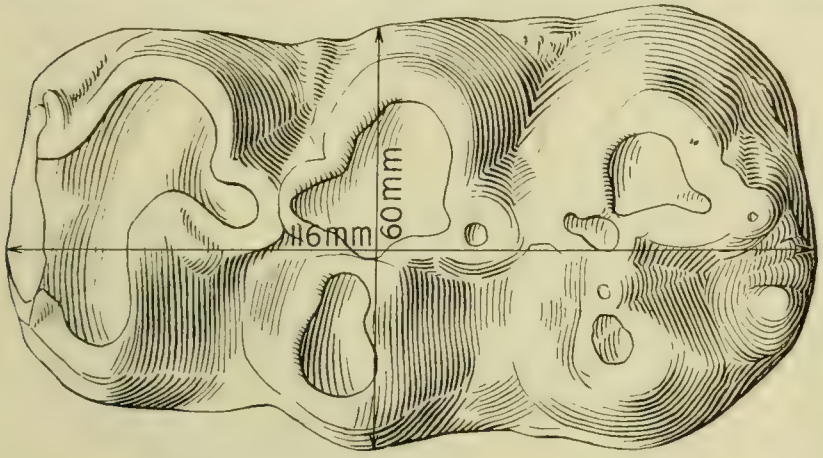
APPENDIX TO CHAPTER VIII

CAST OF CUVIER'S ORIGINAL TYPE OF MASTODON ANGUSTIDENS

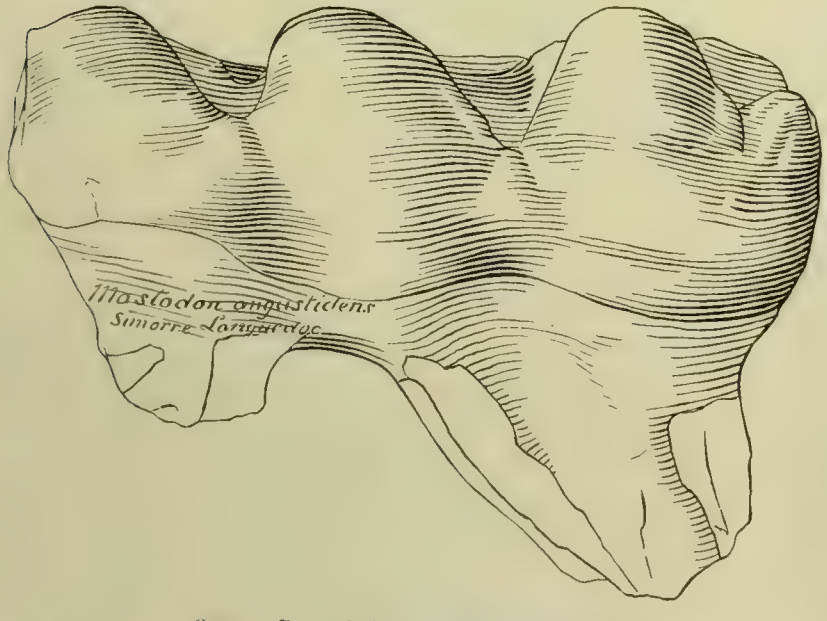
COMPARE CUVIER'S DETAILED TYPE DESCRIPTION OF THIS INFERIOR MOLAR ON PAGE 252 OF THE PRESENT CHAPTER

An indescribably welcome acquisition, after this chapter was in page proof, was one of *two casts* of the original type of *Mastodon angustidens* sent by Cuvier himself to Dr. Gideon Mantell, donated to the American Museum (Amer. Mus. 21921) by the British Museum through Dr. Arthur T. Hopwood, as described in the following excerpt from his letter of April 2, 1927:

> Under a separate cover there is being sent to you a cast of the type specimen of *Mastodon angustidens* Cuvier. Apart from any scientific value of the specimen I think that you will agree that it is also of historical interest. The cast is one of two sent to Gideon Mantell by Cuvier himself and came here many years ago when the Museum acquired the Mantell Collection. This was either in 1839 or 1852—the collection came in two instalments. Since the original is either lost or mislaid these casts are of additional value.



Type Cast - Mastodon angustidens Cuv. - Am. Mus. 21921
Brit. Mus. 7425



ONE OF CUVIER'S TWO CASTS. NATURAL SIZE

Fig. 299. New figure of the type of *Mastodon angustidens* Cuvier, after type cast in the Mantell Collection (Brit. Mus. 7425, Amer. Mus. 21921), bearing the inscription "*Mastodon angustidens*, Simorre, Languedoc." A second right inferior molar, r.M_2, crown and internal aspects. Natural size. The measurements (indicated by arrows), namely, ap. 116 mm., tr. 60 mm., agree with Cuvier's original description.

This cast is one of the two found in the Mantell Collection and bears the inscription (possibly in Cuvier's handwriting): "Mastodon angustidens, Simorre, Languedoc"; it constitutes a palæontologic document of such importance, that we reproduce it in a life-size figure, showing the exact size and proportions as compared with Cuvier's original figure (Figs. 78 and 190 of this Memoir) drawn in perspective and giving an inaccurate idea of the proportions. The present new type figure of this classic species (Fig. 299) corresponds exactly with Cuvier's measurements, namely, ap. 116 mm., tr. 60 mm. across the second ridge-crest, breadth-length index 52.

The observer will note the *conules* directly in the middle of the valleys so distinctive of *Trilophodon*, $M_{1\text{-}3}$, showing the manner in which the worn conule forms the central trefoil distinctive of the lower grinders of this classic species.

HOPWOOD (LETTER, JUNE 13, 1927).—"There are three specimens still preserved in the [Musée d'Histoire Naturelle] Jardin des Plantes which are definitely part of the series studied and figured by Cuvier.

A right second lower molar (Cuvier, *op. cit.*, pl. 1, fig. 4)
Registered Number A. C. 1842.
Length.....115 mm. [116]
Breadth..... 64 [60]
[LECTOTYPE of Osborn in present Memoir (Figs. 78, 190, 299)]

A right lower M3 (Cuvier, *op. cit.*, pl. iii, fig. 3)
Registered Number A. C. 1921.
Length.....94+mm
Breadth.....66
[Marked "TYPE" in the Mus. d'Hist. Nat.]

A right upper PM4 (Cuvier, 1812, Oss. Foss., II, pl. 1, fig. 2)
Registered Number A. C. 1817.
Length.....39.5 mm.
Breadth.....34.5
[Marked "TYPE" in the Mus. d'Hist. Nat.]"

Hopwood agrees that the second lower molar (Fig. 299) should be taken as the *type* (i.e., lectotype), because of its "page priority." Boule does not distinguish this right second lower molar (A. C. 1842) as the type, and the two other specimens are labeled TYPE, namely, r.Pm^4 (A. C. 1817) and r.M_3 (A. C. 1921).

CENTRAL CONULES DISTINCTIVE OF TRILOPHODON (CF. FIGS. 222, 300)

Cuvier's '*Mastodon*' *angustidens* type (Fig. 299) is in about the same stage of evolution as the type of *Trilophodon cooperi* (Fig. 300). The *central conules*, directly descended from those of *Phiomia osborni*, are highly distinctive; they arise directly in the center of the valleys between the three main ridge-crests; they constitute the 'aristogenes,' as described by Osborn in the year 1933, or new adaptive conical elements, clearly distinguishing *Phiomia* and *Trilophodon* from *Serridentinus* in which the central conules are entirely absent (see Chap. X).

The 'alloiometrons' (Fig. 300) are changes of proportion and size, as expressed in ratios and indices: 73–36.

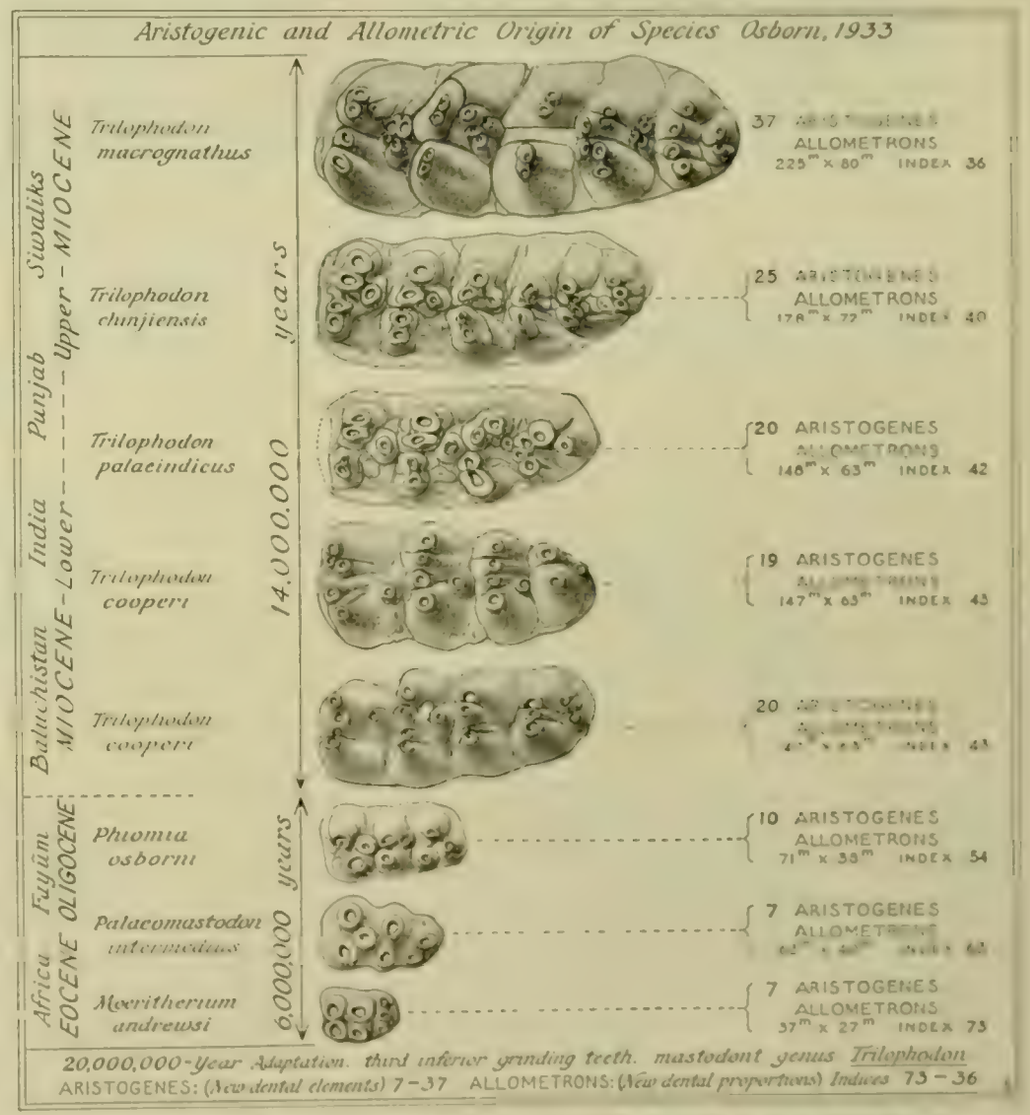


Fig. 300. The 14,000,000-year evolution of the Trilophodonts, from the *Trilophodon cooperi* of Baluchistan to the *T. macrognathus* Mio-Pliocene stage of Chinji, India. Compare figure 222, and Osborn, 1933.911, fig. 1; also compare *T. cooperi* with the somewhat more progressive *T. pontileriensis* (Fig. 230).

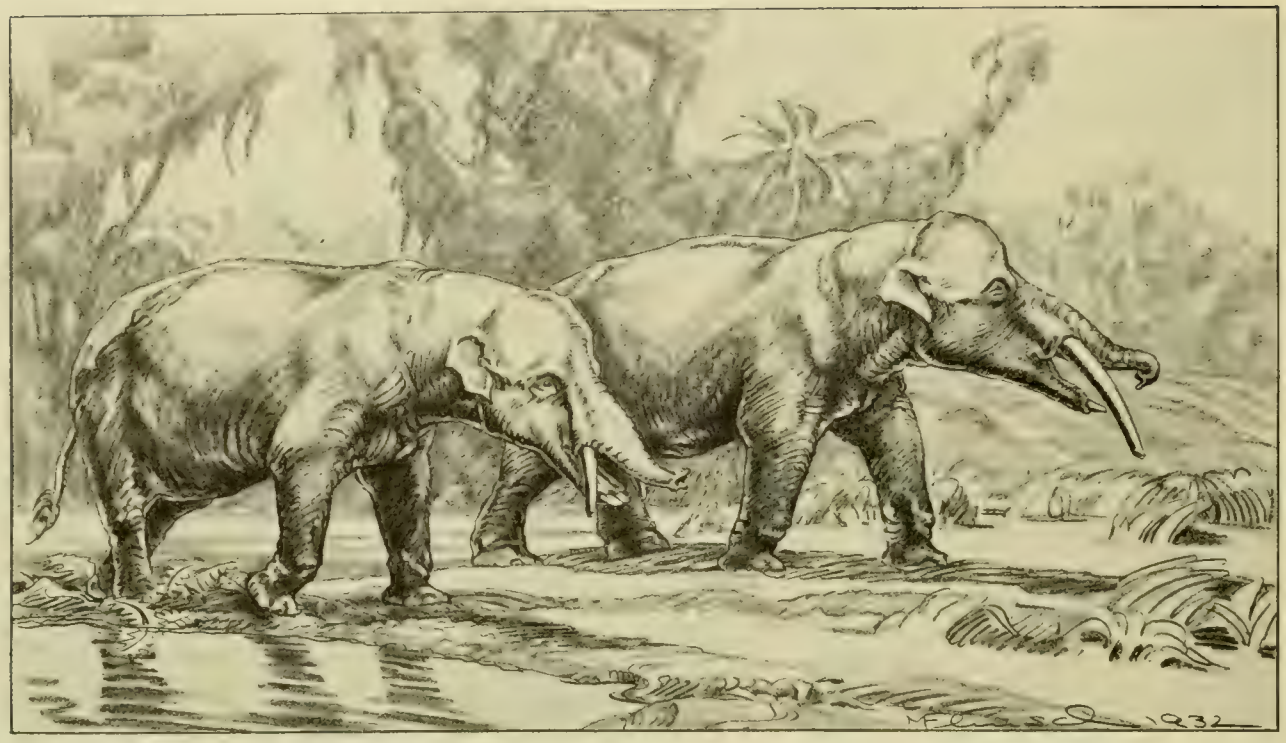


Fig. 301. Tetralophodon punjabiensis of India (Left) and T. campester of Kansas (Right). Restoration (1932) by Margret Flinsch, under the direction of Henry Fairfield Osborn

One-fiftieth natural size

Tetralophodon punjabiensis Lydekker, 1886. The skull on which this restoration was based (Amer. Mus. 19686) was collected by Barnum Brown in 1921–1922, three miles west of Dhok Pathan, India. The right tusk is wanting; the tip of the left tusk shows a lateral enamel band. Estimated shoulder height in the flesh 2475 mm. or 8 ft. $1\frac{3}{8}$ in. Middle Pliocene.

Tetralophodon campester Cope, 1878. Based on portions of the type skull and lower jaw (Amer. Mus. Cope Coll. 8527), from Sappa Creek, Rawlins County, Kansas, Republican River horizon. Estimated shoulder height in the flesh same as that of *T. punjabiensis*, namely, 2475 mm. or 8 ft. $1\frac{3}{8}$ in. Lower Pliocene.

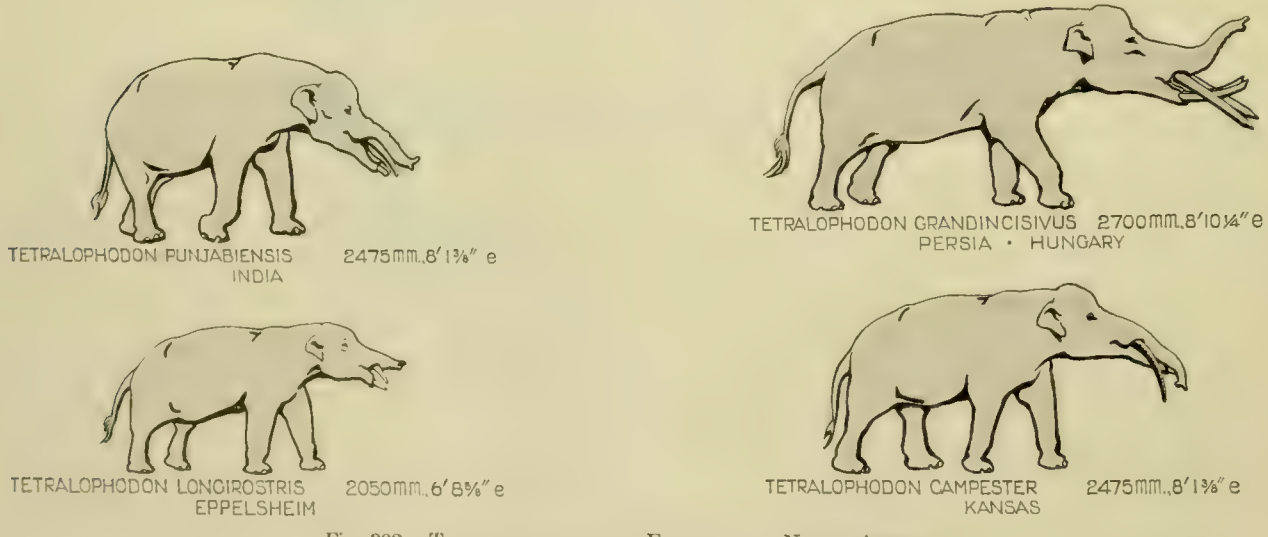


Fig. 302. Tetralophodonts of Eurasia and North America

Uniform scale reconstruction outlines (1932), one-hundredth natural size

Tetralophodon punjabiensis, reconstructed as described above in figure 301.

Tetralophodon longirostris, reconstructed from Kaup's figures of type and referred specimens (Figs. 312–315).

Tetralophodon grandincisivus, reconstructed from Schlesinger's figures of type and referred specimens (Figs. 317–321).

Tetralophodon campester, reconstructed from Cope's type (Figs. 330, 331).

Chapter IX

HISTORY OF THE SUBFAMILY TETRALOPHODONTINÆ. ORIGIN AND GEOGRAPHIC DISTRIBUTION OF THE MEDIUM-JAWED MASTODONTS OF THE PHYLUM TETRALOPHODON

Distinctions between the well-known genus Trilophodon, the doubtful subgenus Lydekkeria (Miocene stage of the genus Tetralophodon), the true brachyodont Tetralophodon phylum terminating in the final hypsodont subgeneric stage Morrillia. Phyletic history and migrations of the medium-jawed Lydekkeria, Tetralophodon, and Morrillia.

1. Distinctions between the *Trilophodon* phylum and the *Tetralophodon* phylum, including the typical genus *Tetralophodon* and the very progressive subgenus *Morrillia*.
   The subgenus *Lydekkeria* (Miocene stage of *Tetralophodon*) becomes doubtful (1932).
2. Distinctions between the deciduous dentition of *Tetralophodon* and *Trilophodon*. Compare pages 261–266. *Tetralophodon* and *Synconolophus* contrasted.
3. Phylum *Tetralophodon* Falconer, including the doubtful *Lydekkeria*, the more progressive and typical *Tetralophodon*, and the highly specialized *Morrillia*. Order of discovery, description, and phylogeny.
4. Probable origin of *Tetralophodon*. Characters of the primitive subgenus *Lydekkeria*, as known in the Pliocene of India and in the Miocene or Pliocene of China.
5. Characters of the typical genus *Tetralophodon* of Falconer, including species migrating from Eurasia to the west central United States.
6. Eurasiatic species of *Tetralophodon*, chiefly Lower Pliocene, namely, *T. longirostris*, *T. grandincisivus*, and *T. punjabiensis*.
7. *Tetralophodon* from Java.
8. American species of *Tetralophodon*, of Lower to Middle Pliocene age, namely, *T. campester* and *T. elegans*.
9. *Tetralophodon fricki* sp. nov., from the Pliocene of Texas.
10. Final hypsodont subgeneric stage of *Tetralophodon*, namely, *T.* (*Morrillia*) *barbouri*, II Glacial, Middle Pleistocene.
11. Summary of evolution and migration.

(November, 1932) After this chapter went into first page proof (July, 1922) it was found that the genotype of *Lydekkeria*, namely, *Mastodon falconeri* Lyd., was of Middle Pliocene, Dhok Pathan age, instead of Miocene age as recorded by Lydekker, 1877, and Pilgrim, 1922–1927, and a contemporary of *M. punjabiensis* Lyd., 1886. Thus, unfortunately, the generic definition and description of *Lydekkeria* (pp. 353–355) are partly invalidated too late for alteration throughout.

1. DISTINCTIONS BETWEEN THE TRILOPHODON PHYLUM AND THE TETRALOPHODON PHYLUM, INCLUDING THE TYPICAL GENUS TETRALOPHODON AND THE VERY PROGRESSIVE SUBGENUS MORRILLIA

The present chapter opens with the distinctions which, from our limited knowledge, appear to exist between the well-known genus *Trilophodon* and the *Tetralophodon*, *Lydekkeria*, and *Morrillia* phylum. The subgenus *Lydekkeria* Osborn, 1924, based on the genotype (Fig. 309) '*Mastodon falconeri*' Lydekker, 1877, of supposed Middle Miocene age, now proves to be of Middle Pliocene age, hence contemporaneous with the *Tetralophodon punjabiensis* Lydekker, 1886. This leaves the Miocene ancestry of *Tetralophodon* uncertain (see Hopwood, letter, Feb. 10, 1932, p. 353, below). In *Trilophodon* M 2 is trilophoid; in *Tetralophodon* M 2 is tetralophoid (see Fig. 303); other phyletic and progressive generic distinctions are as in the table below.

Separation of Tetralophodon by Falconer, 1868.—The beautiful figure (Fig. 303) given by Falconer in his "Palæontological Memoirs" of 1868, and reproduced in facsimile here, demonstrates that Falconer himself had a clear conception of the profound differences between *Trilophodon* and *Tetralophodon*, although he clung to

Trilophodon Phylum		Tetralophodon Phylum	
Trilophodon Falconer	(?)Syn. *Choerolophodon* Schlesinger	(?)S.g. *Lydekkeria* Osborn	*Tetralophodon* Falconer S.g. *Morrillia* Osborn
Lower incisive tusks in both males and (?)females		Lower incisive tusks (?) chiefly in males	
Hyperlongirostral. 'Intermediate molars' trilophodont. Cones and conelets regular with simple, smooth enamel. Single 'central conules' and trefoils; doubling of the trefoils retarded.	Medilongirostral. 'Intermediate molars' trilophodont. Cones and conelets irregular, chærodont. Single 'central conules.'	Medilongirostral. 'Intermediate molars' subtetralophodont. Cones relatively smooth and regular. Doubling of the trefoils incipient. 'Central conules' doubtful.	Medilongirostral. 'Intermediate molars' tetralophodont. Cones relatively smooth and regular. Doubling of the trefoils progressive. 'Central conules' variable.
Persistent brachyodonty.	Brachyodont. [Juvenile type.]	Brachyodont.	Brachyodont to subhypsodont.
E.g., *Trilophodon angustidens* progressive to *Trilophodon macrognathus*, etc. Miocene and Pliocene.	E.g., *Trilophodon*(*Choerolophodon*) *pentelicus*. Lower Pliocene.	E.g., *Tetralophodon* (*Lydekkeria*) *falconeri*. Miocene and Pliocene.	E.g., *Tetralophodon longirostris*. Lower Pliocene.
			Subhypsodont to hypsodont; cement. E.g., *Tetralophodon* (*Morrillia*) *barbouri*. Middle Pleistocene.

Fig. 4

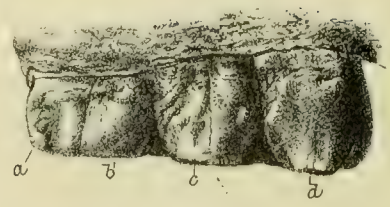


Fig. 1

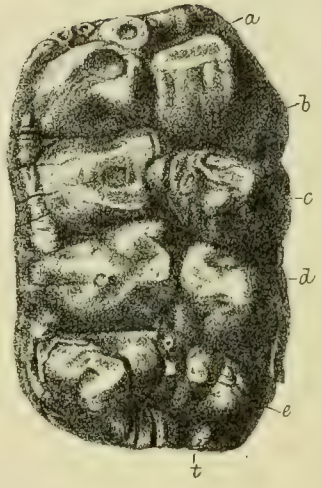


Fig. 3.

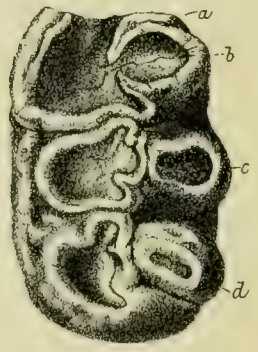
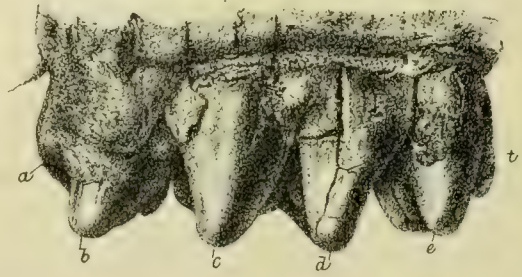


Fig. 2.



G.H.Ford del. J.Dinkel lith.

1-2. Mastodon (Tetralophodon) longirostris. 3-4. M. (Trilophodon) angustidens.

SUPERIOR INTERMEDIATE MOLARS OF TETRALOPHODON (LEFT), OF TRILOPHODON (RIGHT)

Fig. 303. Superior intermediate molars, M^2, as figured by Falconer, 1868, Vol. II, Pl. III, to illustrate the generic differences between (figs. 1, 2) *Mastodon* [= *Tetralophodon*] *longirostris* Kaup from Eppelsheim, and (figs. 3, 4) *Mastodon* [= *Trilophodon*] *angustidens* Cuvier from Sansan (?), Gers.

the idea that they ranked under the genus *Mastodon*, as shown in his legend reproduced herewith (Fig. 303): "1–2. Mastodon (Tetralophodon) longirostris. 3–4. M. (Trilophodon) angustidens." These are the corresponding teeth in the two phyla, namely, M^2 in crown view (Figs. 1, 3) and in internal view (Figs. 2, 4). The *T. longirostris* tooth is from the type locality of Eppelsheim, and the *T. angustidens*

tooth is from Sansan (?), Gers; the former is tetralophodont, the latter trilophodont; both teeth are brachyodont. We observe that *Tetralophodon longirostris* is slightly more brachyodont than the American species *Tetralophodon campester* of the same Lower Pliocene age; *T. (Morrillia) barbouri* is decidedly hypsodont (Figs. 308, 329).

Phylogeny.—It has erroneously been assumed by some authors that animals of the *Trilophodon angustidens* type gave rise to animals of the *Tetralophodon* type by abbreviation of the jaw and by the addition of a fourth crest on the intermediate molars, especially P^1-P_4 M^1-M_1 M^2-M_2. This assumption is disproven by three facts: (1) That the true *Trilophodon* persisted after the true *Tetralophodon* had appeared; (2) that *Tetralophodon* is a Medilongirostrine, whereas *Trilophodon* is a Hyperlongirostrine; (3) that a true ancestral species of *Tetralophodon* (*Lydekkeria*), e.g., *Mastodon* [=*Tetralophodon* (*Lydekkeria*)] *falconeri* Lydekker, is recorded in the Middle Pliocene, Dhok Pathan beds, of India. The outstanding distinctions between *Tetralophodon* and *Trilophodon* are therefore the following:

1. Genus *Trilophodon* Falconer. Miocene and Pliocene.
Genotype: *Mastodon angustidens* Cuvier.

Fourth premolars and first and second superior and inferior molars trilophodont. Dp^4-Dp_4 also trilophodont.

Third inferior molars persistently tetralophodont to pentalophodont, i.e., four to four and a half crests; rarely to five and a half crests.

Molars persistently brachyodont.

Molars with persistent single central trefoils; rudiments only of double trefoils in late geologic stages.

Central conules invariably present.

Jaw progressively elongating (hyperlongirostral); tusks progressive.

2. Genus *Tetralophodon* Falconer. Mio-Pliocene to Middle Pleistocene.
Genotype: *Mastodon longirostris* Kaup.

Fourth premolars and first and second superior and inferior molars tetralophodont. Dp^4-Dp_4 also tetralophodont.

Third superior and inferior molars progressively pentalophodont to octalophodont adding crests, e.g., five and a half crested, six crested, seven and a half to eight and a third crested.

Molars progressively brachyodont to subhypsodont, to hypsodont (*Morrillia*) and covered with cement.

Molars with double central trefoils in early Pliocene stages.

Central conules variable, present or absent.

Jaw stationary at medium length (medilongirostral); inferior tusks retrogressive, (?) absent in females.

Adult Ridge Formulæ. — Whereas in all the thirty-seven species which we have more or less provisionally referred to the genus *Trilophodon* the ridge formula remains relatively constant and conservative, viz., $M\ 3\frac{4\text{-}4\ 1/2}{4\ 1/2\text{-}5\ 1/2}$, in *Tetralophodon* the ridge formula is progressive, thus, $M\ 2\frac{\cdot\text{-}\cdot\ 3}{\cdot\text{-}\cdot\ 3}$ $M\ 3\frac{\cdot\text{-}\cdot\ 3}{\cdot\text{-}\cdot\ 3}$. *Tetralophodon*, however, is much less fully known than *Trilophodon* and the species which are referred to the *Tetralophodon* generic phylum in the list below are partly provisional.

Deciduous Ridge Formulæ.—It is very important to observe that in both the deciduous and permanent dentition of *Trilophodon* and *Choerolophodon*, the 'intermediate molars,' namely, Dp 4-M 2, are three crested or *trilophodont*, whereas in *Tetralophodon* the corresponding deciduous and permanent intermediate molars are *tetralophodont*. Accordingly, as shown in figure 304, the fourth superior milk premolars of *Trilophodon angustidens* (Fig. 304, lower) are *three crested*, practically as in the fourth superior milk premolars of *Mastodon* [= *Trilophodon* (*Choerolophodon*)] *pentelicus* (Fig. 304, middle), whereas the fourth superior milk premolars of *Mastodon* [= *Tetralophodon*] *longirostris* are *four crested* (Fig. 304, upper). Central conules are typically reduced or *absent*.

2. DISTINCTIONS BETWEEN THE DECIDUOUS DENTITION OF TETRALOPHODON AND TRILOPHODON (COMPARE PAGES 261–266)

Trilophodon.—The juvenile type skull, which Gaudry and Lartet in 1856 described as *Mastodon pentelicus*, contains only the deciduous superior and inferior incisors and premolars, as beautifully shown and described in Gaudry's great memoir of 1862, Pl. xxii, and reproduced in his "Les Enchainements du Monde Animal," 1878, p. 180. It is upon the coronal characters of these milk teeth, reproduced in facsimile in figure 304, as

compared with those of *Trilophodon angustidens* on the one hand and of *Tetralophodon longirostris* on the other, that the generic distinction between *Trilophodon* (*Choerolophodon*) *pentelicus* and *Tetralophodon longirostris* can readily be made. In this comparison we observe the following ridge formulæ:

Fig. 240. — Molaires supérieures de lait du *Mastodon longirostris*, aux 2/3 de grandeur. — 1*m*. première molaire; 2*m*. seconde molaire à trois collines; 3*m*. troisième molaire à quatre collines. — Miocène supérieur d'Eppelsheim. (D'après M. Kaup.)

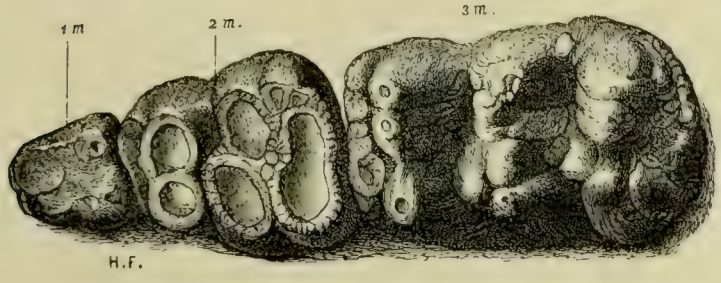


Fig. 241. — Molaires supérieures de lait du *Mastodon Pentelici*, aux 2/3 de grandeur. — 1*m*. première molaire; 2*m*. seconde molaire à trois collines; 3*m*. troisième molaire à trois collines. — Miocène supérieur de Pikermi.

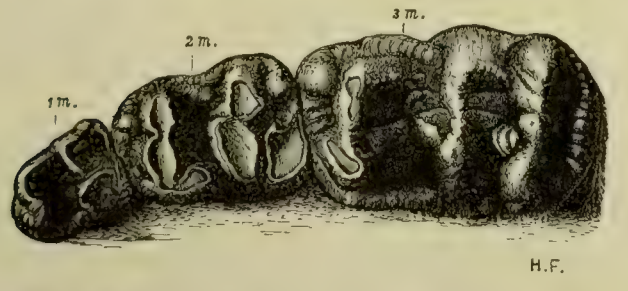


Fig. 239. — Molaires supérieures de lait du *Mastodon angustidens*, aux 2/3 de grandeur. — 1*m*. première molaire; 2*m*. seconde molaire à deux collines; 3*m*. troisième molaire à trois collines. — Miocène moyen de Sansan.

Fig. 304. Superior milk premolars of the left maxilla, *Tetralophodon*, *Choerolophodon*, *Trilophodon*. For full explanation of this figure, see figure 196 above (*Trilophodon*, Chap. VIII).

(Upper figure, 240) *Mastodon* [= *Tetralophodon*] *longirostris* of Eppelsheim, Dp^4 with four and a third crests.

(Middle figure, 241) *Mastodon* [= *Trilophodon* (*Choerolophodon*)] *pentelicus* of Pikermi, Dp^4 with three and a third crests.

(Lower figure, 239) *Mastodon* [= *Trilophodon*] *angustidens*, Dp^4 with three crests.

	Dp^2	Dp^3	Dp^4	[M^1
Tetralophodon longirostris	1½ crests	3 crests	4⅓ crests	4½ crests
Trilophodon (*Choerolophodon*) *pentelicus*	1½ crests	3 crests	3⅓ crests	3½ crests
Trilophodon angustidens	1½ crests	2½ crests	3 crests	3 crests]

Unfortunately we do not yet know the adult structure of the grinding teeth in the stage of what we call *Trilophodon* (*Choerolophodon*) *pentelicus*, for no adult dentition has been described. It is certain, however, that this animal belongs to *Trilophodon pentelicus* (see Chap. VIII, pp. 261–266).

Schlesinger (1917, p. 181) solved the difficulty by proposing to call this animal *Choerolophodon*, making *Mastodon pentelicus* the type of his new subgenus characterized by the crenulate or chœrodont condition of the milk-molar crowns. The juvenile skull of '*M.*' *pentelicus*, beautifully figured by Gaudry, as reproduced above in two figures (Figs. 205, 206), reveals the following additional characters: (1) Intermediate milk molars, Dp^{3-4}, trilophodont in ridge formula, (2) bunolophodont and chœrodont in cone structure; (3) enamel band on outer side of superior tusks; (4) lower jaw moderately elongated; (5) superior milk molars certainly intermediate in character between those of *Trilophodon angustidens* and *Tetralophodon longirostris*.

(1) Compare (Fig. 304) the above superior milk teeth, Dp^2 to Dp^4, with those of *Phiomia wintoni* (cf. *serridens*), figure 181, and observe the progression in the ridge formula; (2) observe also the marked crenulation of the sides of the lophs; and (3) the progressive evolution in ascending order of Dp^3 in *P. wintoni* (cf. *serridens*), figure 181, in *Trilophodon angustidens*, in *T.* (*Choer.*) *pentelicus*, and in *Tetralophodon longirostris* in which Dp^3 becomes trilophodont. Dp^4 is trilophodont in *Trilophodon angustidens;* it is trilophodont with a rudiment of a tetartoloph in *T.* (*Choer.*) *pentelicus;* it is tetralophodont with a rudiment of a pentaloph in *Tetralophodon longirostris*.

TETRALOPHODON (TETRALOPHODONTINÆ) CONTRASTED WITH SYNCONOLOPHUS (BREVIROSTRINÆ) OF THE SUMMIT OF THE MIDDLE SIWALIKS OF INDIA

The widest possible contrast is observed between the basicranial, palatal, and grinding tooth aspect of *Synconolophus* (Fig. 305) and *Tetralophodon* (Fig. 306). *Synconolophus* is a typical Brevirostrine; molars asymmetrical with compacted cones and central conules. *Tetralophodon* is a Mediilongirostrine; molars with symmetrical cones and ridge-crests but reducing the central conules seen in *Synconolophus* and *Trilophodon*. Both are subchœrodont. Observe the dolichocrany of *Synconolophus* and the brachycrany of *Tetralophodon*.

Prior to the American Museum Expedition of Barnum Brown in 1921–1924 the genus *Tetralophodon* had been represented from the Siwaliks only by isolated teeth collected and figured by Falconer, Lydekker, and Pilgrim. The fortunate discovery by Doctor Brown of a complete cranium (referred by the present author to *Tetralophodon punjabiensis*) three miles west of Dhok Pathan, 500 feet below the summit of the Middle Siwaliks, India, of typical Middle Pliocene age, greatly extends our knowledge of this genus and affords a complete understanding of the character of the skull in comparison with Kaup's palate of *Mastodon* [= *Tetralophodon*] *longirostris;* in the present Memoir this cranium is represented in figures 306 and 324.

Fig. 305. *Synconolophus dhokpathanensis* type (Amer. Mus. 19673). Palatal view of cranium showing the three and a half crested M^2 and the four crested M^3, also the posterior position of the narial opening. For full description and additional figure, see Chapter XIII (pp. 661–664, Fig. 630).

Fig. 306. *Tetralophodon punjabiensis* ref. (Amer. Mus. 19686). Palatal view of cranium showing the complete structure of the right and left superior molar teeth, one-eighth natural size. For description and additional figure see pages 363, 364, and figure 324.

3. PHYLUM TETRALOPHODON FALCONER, INCLUDING THE DOUBTFUL LYDEKKERIA, THE MORE PROGRESSIVE AND TYPICAL TETRALOPHODON, AND THE HIGHLY SPECIALIZED MORRILLIA. ORDER OF DISCOVERY, DESCRIPTION, AND PHYLOGENY

SUPERFAMILY: MASTODONTOIDEA Osborn, 1921
FAMILY: BUNOMASTODONTIDÆ Osborn, 1921
SUBFAMILY: TETRALOPHODONTINÆ van der Maarel, 1932

PHYLUM TETRALOPHODON

Original reference: Section name, Falconer and Cautley, "Fauna Antiqua Sivalensis," 1846 [1847, Pls. XLII–XLV], based on *Mastodon perimensis, M. sivalensis, M. arvernensis, M. longirostris* and *M. latidens;* subgenus of *Mastodon*, Falconer, Quart. Journ. Geol. Soc. London, 1857, XIII, pp. 313, 316, table opposite p. 319.

HISTORY.—The genus *Tetralophodon*, originally proposed by Falconer in 1847 as a collective or section name to include five species which we now recognize as belonging to at least four distinct genera, is by courtesy to Falconer restricted to one of the five species, namely, *Mastodon longirostris*. His definition of 1857 (p. 316) is as follows: "Subgenus 2. *Tetralophodon.*—Dent. molar. 3, utrinque intermediorum coronis colliculis 4 (raro 5)." As partly restricted by Falconer himself to *M. longirostris* in 1857, we may study the characters of this animal as the genotypic species of the genus *Tetralophodon.*

PHYLETIC CHARACTERS.—Imperfectly known Medilongirostrines, with tetralophodont intermediate molars, single trefoils in the Miocene stage, double trefoils in the Pliocene stage; brachyodont, progressive to hypsodont, with cement, in Pleistocene time; third molars slowly developing from 4½ (?) to 7½ to 8⅓ ridges; third grinders only in use in old age. Compare also the generic characters listed above (pp. 344, 345).

Whereas *Trilophodon* is of Lower Miocene to Middle Pliocene age, *Tetralophodon* first appears abundantly in Lower Pliocene time and extends into Middle Pliocene time. Thanks to the recent geologic observations of Lugn and Schultz (Pls. VII, VIII of the present Memoir), this phylum survived to Middle Pleistocene time in the progressively hypsodont *T.* (*Morrillia*) *barbouri* of Nebraska.

This generic phylum appears to be geologically first known in southern Asia, namely, in the Middle Pliocene *Tetralophodon* (*Lydekkeria*) *falconeri* of India and in the Mio-Pliocene *T.* (*L.*) *sinensis* of China; Miocene species are distinguished by their incipient trefoils from the Pliocene genotype, *T. longirostris*, which has double trefoils. The *T.* (*Lydekkeria*) *falconeri* of the Dhok Pathan horizon, Middle Siwaliks, passes into the form of the Middle Pliocene *T. punjabiensis* of the Dhok Pathan, India, from the *Tetralophodon longirostris* stage of Germany. Four or more American species are known, namely, *Tetralophodon campester* and *T. elegans*, Lower to Middle(?) Pliocene of Kansas, and the primitive *T. fricki* sp. nov., Pliocene of northern Texas, also *Tetralophodon* (*Morrillia*) *barbouri*, Middle Pleistocene of Nebraska. Klähn (1922) described the species *Mastodon gigantorostris* from Bermersheim, Germany, which appears to be referable to *Tetralophodon* (see Chap. VIII, p. 282, for brief description). Van der Maarel has recently (1932) added *Tetralophodon bumiajuensis* from the Pliocene of central Java.

Of the following fifteen[1] species the majority are very imperfectly known; it is probable but not certain that they all belong in the phylum *Tetralophodon.*

(1) The Eurasiatic Miocene member, *Tetralophodon sinensis*, has *single* trefoils and is referable to the distinct and more primitive new subgenus *Lydekkeria*. (2) The Eurasiatic and American Pliocene members, *T. grandincisivus, T. longirostris, T. punjabiensis, T. campester*, and *T. elegans*, have incipient double trefoils and are referable to Falconer's genus *Tetralophodon*. (3) *T. barbouri* belongs to the final stage *Morrillia* Osborn, with hypsodont molars, heavy cement, and double trefoils (Fig. 308).

[1]See footnote on page 349.

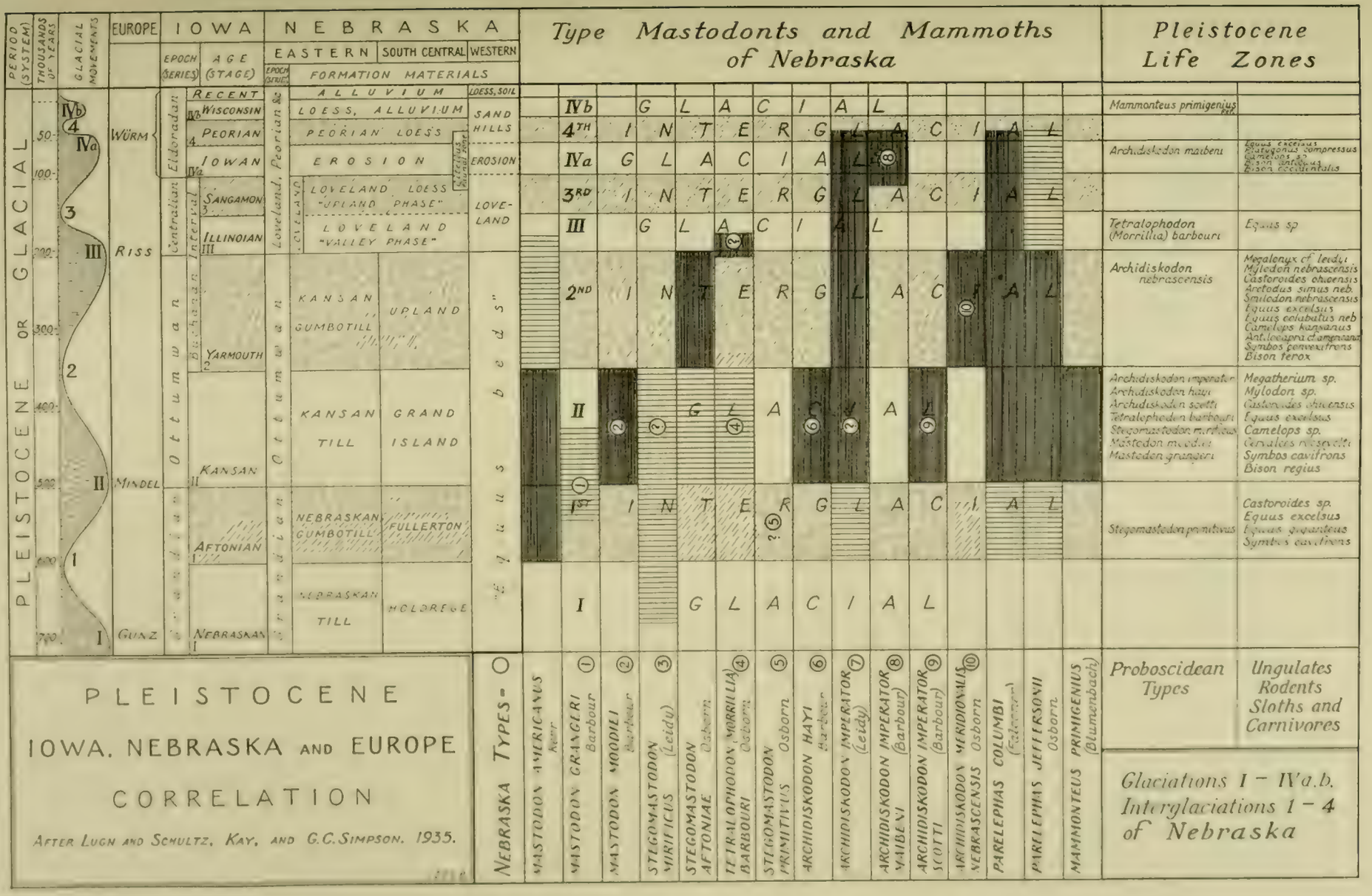


PLATE VIII

PLEISTOCENE SUCCESSION OF THE MASTODONTINÆ, HUMBOLDTINÆ, TETRALOPHODONTINÆ, AND MAMMONTINÆ OF AMERICA

FOR THE LONGIROSTRINÆ, AMEBELODONTINÆ, PLATYBELODONTINÆ, AND GNATHABELODONTINÆ, SEE PLATE VII

PRELIMINARY ESTABLISHMENT OF THE PLEISTOCENE LIFE ZONES OF IOWA, NORTHERN KANSAS, AND NEBRASKA, IN CORRELATION WITH THE SEDIMENTS OF GLACIATIONS I–IV AND INTER-GLACIATIONS 1–4. SHADED COLUMNS REPRESENT THE RANGE IN NEBRASKA ONLY

This chart marks a most remarkable step forward in the paleontology of the Ice Age of America. When studied and confirmed by additional field observations and research, it will afford an accurate record of the times of entrance into America of the great elephantoids from Eurasia and Africa; also of the times of arrival from South America and the times of extinction of the characteristic American fauna. The elephantoids will be fully commented on in Volume II.

Of the mastodontoids there are three survivals of the Humboldtinæ, namely, *Stegomastodon primitivus*, *S. mirificus*, and *S. aftoniæ*. Most surprising is the survival of *Tetralophodon* (*Morrillia*) *barbouri* into III Glacial time. The Mastodontinæ arrived in II Glacial time.

Fig. 307. Geographic distribution of species of *Tetralophodon*. The white dots within the black areas represent the approximate localities where the types of these fifteen[1] species were discovered. The crosses represent referred specimens mentioned in the present Memoir.

CHRONOLOGIC ORDER OF DISCOVERY AND DESCRIPTION

See Figure 307

		Original Name	Specific Reference in Present Memoir	Geologic Age
1.	1832	*Tetracaulodon longirostre* Kaup, Eppelsheim, Germany	= *Tetralophodon longirostris*	Lower Pliocene
2.	1834	*Mastodon dubius* Kaup and Scholl, Eppelsheim, Germany	= *Tetralophodon longirostris*	Lower Pliocene
3.	1834	*Mastodon grandis* Kaup and Scholl, Eppelsheim, Germany	= *Tetralophodon longirostris*	Lower Pliocene
4.	1877	*Mastodon* (*Trilophodon*) *Falconeri* Lydekker, Dhok Pathan, Potwâr district, Punjab, India (*fide* Hopwood letter, 1932)	= *Tetralophodon* (*Lydekkeria*) *falconeri*	Middle Pliocene
5.	1885	*Mastodon perimensis* Falconer var. *sinensis* Koken, Yun-nan, China	= *Tetralophodon* (*Lydekkeria*) *sinensis*	Miocene(?) to Pliocene(?)
6.	1886	*Mastodon punjabiensis* Lydekker, Dhok Pathan, Siwaliks, India	= *Tetralophodon punjabiensis*	Middle Pliocene
7.	1878	*Tetralophodon campester* Cope, Republican River horizon, Sappa Creek, Kansas	= *Tetralophodon campester*	Lower Pliocene
8.	1917	*Mastodon* (*Bunolophodon*) *grandincisivum* Schlesinger, Maragha, Persia	= *Tetralophodon grandincisivus*	Lower(?) Pliocene
9.	1917	*Gomphotherium elegans* Hay, McPherson, Kansas	= *Tetralophodon elegans*	Middle (?) Pliocene
10.	1921	*Tetralophodon barbouri* Osborn, Cambridge, Furnas County, Nebraska	= *Tetralophodon* (*Morrillia*) *barbouri*	Middle Pleistocene
11.	1922	*Mastodon gigantorostris* Klähn, Bernersheim, Germany	= *Tetralophodon gigantorostris*	Lower Pliocene
12.	1923	*Tetralophodon precampester* Osborn, Harlan County, Nebraska	= *Tetralophodon* (*Morrillia*) *barbouri*	Middle Pleistocene
13.	1923	*Anancus brazosius* Hay, Brazos River, near San Felipe, Texas	= *Trilophodon* (?*Tetralophodon*) *brazosius*[1]	(?)Pliocene
14.	1932	*Tetralophodon bumiajuensis* van der Maarel, Bumiaju, central Java	= *Tetralophodon bumiajuensis*	Pliocene
15.	1933	*Tetralophodon fricki* sp. nov., northern Texas	= *Tetralophodon fricki*	Lower to Middle Pliocene

[1] *Anancus brazosius* transferred (1935) to *Trilophodon* (see Fig. 333, p. 374, below). Consequently *Trilophodon brazosius* appears erroneously on the above map (Fig. 307); see footnote on page 250.

Tetralophodon exoletus Hopwood, 1935, Lower Pliocene of China (see Appendix to present Volume I).

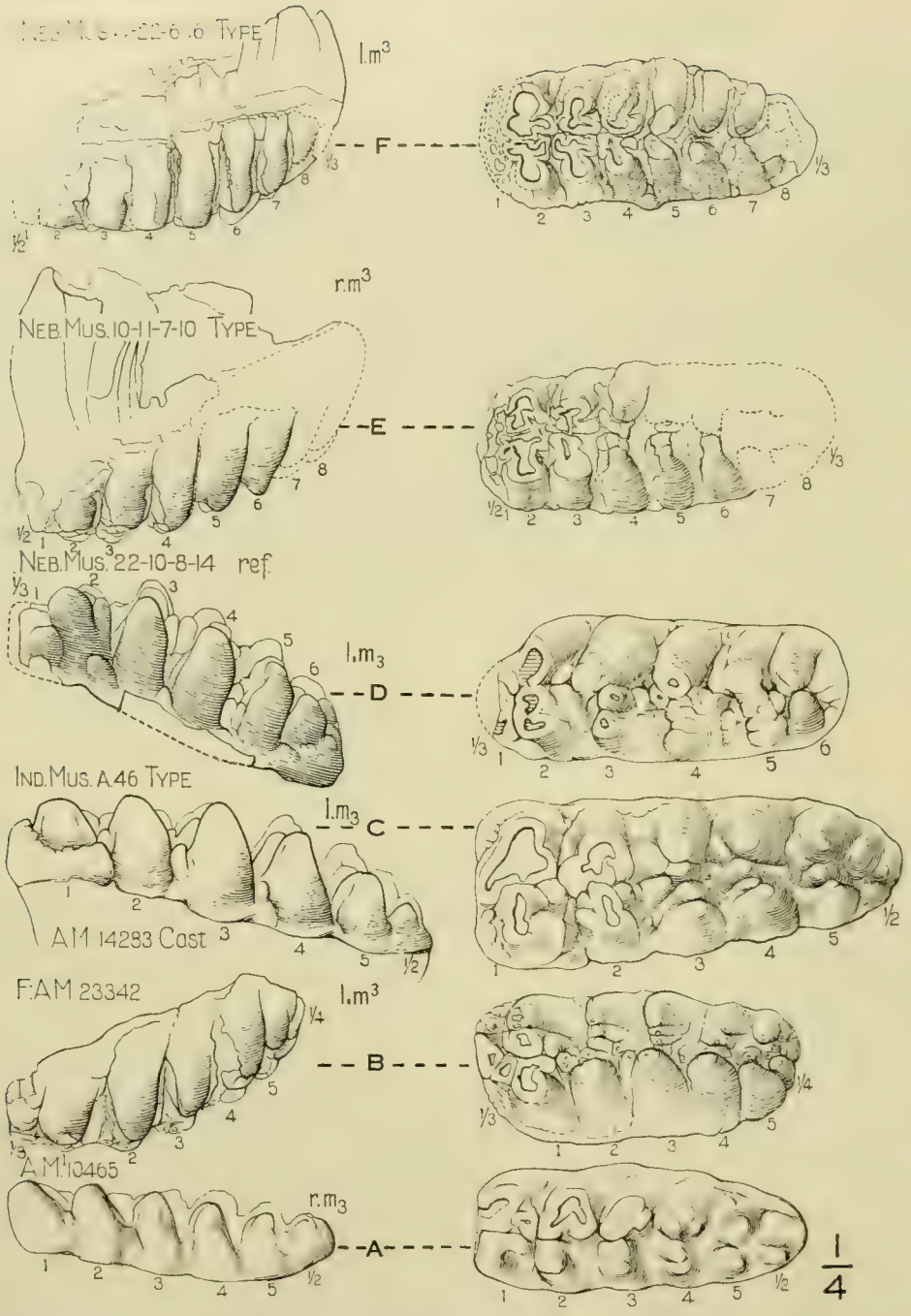


Fig. 308. Anteroposterior evolution and hypsodonty of third inferior and superior molars in *Tetralophodon*, from the base to the summit of the Pliocene. Observe in B, D, F a rudimentary anterior crest. Compare figure 329.

This unique series of figures exhibits the following: (1) Progressive addition of anterior as well as of posterior ridge-crests; (2) progressive vertical elongation of the crests from brachyodonty in *Tetralophodon longirostris* to full hypsodonty in *T.* (*Morrillia*) *barbouri*; (3) progressive strengthening of the internal and external trefoils, feebly developed in *T. precampester* and *T. longirostris*, strongly developed in *T.* (*Morrillia*) *barbouri*; (4) progressive addition of cement; (5) progressive increase in size.

F, *Tetralophodon* (*Morrillia*) *barbouri* Osborn, type, by far the most progressive stage, hypsodont, cement, ridge-crests M 3 $\frac{7\frac{1}{2}-8\frac{1}{2}}{}$.

E, *Tetralophodon precampester* type = *T.* (*Morrillia*) *barbouri* ref.; ridge-crests M $3\frac{1\frac{1}{2}-8}{}$.

D, *Tetralophodon campester* Cope, ref., subhypsodont, slight cement, ridge-crests M 3 $\frac{}{6\frac{1}{2}}$.

C, *Tetralophodon punjabiensis* Lydekker, type (new figure), less hypsodont, no cement, ridge-crests M 3 $\frac{}{5\frac{1}{2}+}$.

B, *Tetralophodon fricki* sp. nov., type, slight cement, subhypsodont, double trefoils feebly developed, ridge-crests M 3 $\frac{1\frac{1}{2}-5-1\frac{1}{2}}{}$. Central conules. Compare Fig. 334, p. 375.

A, *Tetralophodon longirostris* Kaup, type (new figure), brachyodont, no cement, trefoils feebly developed, ridge-crests M 3 $\frac{}{5\frac{1}{2}}$.

Consequently these animals include three generic stages. (1) The doubtful subgenus *Lydekkeria* rests upon the Middle Pliocene stage of *Mastodon* (*Trilophodon*) *falconeri*. (2) The genus *Tetralophodon* Falc. rests upon the typical Lower Pliocene stage of Eppelsheim, with incipient double trefoils and relatively short-crowned molars, i.e., brachyodont. (3) The Middle Pleistocene stage, *T.* (*Morrillia*) *barbouri*, is fully hypsodont; when more perfectly known it may be embraced in a third genus, to which the name *Morrillia* would be appropriately applied, as the genotypic species (see Fig. 308 on opposite page).

ASCENDING PROGRESSIVE ORDER AND CHARACTERS OF SPECIES

Specimens of *Tetralophodon* are much more rare than those of *Trilophodon*. Until the recent discovery of the fine skull of *T. punjabiensis* (see Figs. 306, 324), there were only two partly complete skulls known, namely, of *Tetralophodon longirostris* of Eppelsheim and of *T. campester* of Kansas, the remaining species rested mainly on isolated superior and inferior molars, so that we were very far from knowing the full characters or evolution of this genus.

Immediately above, in this *Tetralophodon* section, the species are listed in the order of discovery. An attempt may now be made to list them in ascending order of phylogenetic evolution, with the comparative measurements and indices so far as we can give them from our present knowledge.

PHYLOGENETIC ORDER.—The theoretic ascending order of eleven of the fifteen[1] species provisionally referred to this phylum is as follows:

			Second Molars				Third Molars			Ridge-crests	
			ap.	tr.	I.		ap.	tr.	I.	M 2	M 3
Middle Pleistocene	1921	*Tetralophodon* (*Morrillia*) *barbouri* type, M^3, Cambridge, Nebraska	Unknown			M^3	204c	84c	41c		7½-8½
Middle Pleistocene	1923	*Tetralophodon precampester* = *T.* (*Morrillia*) *barbouri*, M^3, Harlan County, Nebraska				M^3	177c	88c	50c		½-8
Middle to Upper Pliocene	1917	*Tetralophodon elegans* type, M_3, McPherson, Kansas				M_3	217	85	39		5½-6
Lower Pliocene	1878	*Tetralophodon campester* type, M^{2-3}, Republican River horizon, Sappa Creek, Kansas	118	75	64	M^3	195	80	41		½-6
Lower to Middle Pliocene	1933	*Tetralophodon fricki* type, M^{2-3}, northern Texas	128	73	57	M^3	182	89	49		½-5-½
Middle Pliocene	1886	*Tetralophodon punjabiensis* lectotype, M_3, Dhok Pathan, Siwaliks, India				M_3	242	93	38		5½+
Lower Pliocene	1832	*Tetralophodon longirostris* type, M_{2-3}, Eppelsheim, Germany	138	67	49	M_3	189	70	37	4½	5½
Lower(?) Pliocene	1917	*Tetralophodon grandincisivus* ref., M^3, Maragha, Persia				M^3	225	106	47		5½
Middle(?) Pliocene	1877	*Tetralophodon* (*Lydekkeria*) *falconeri* type, M_2, Dhok Pathan, Punjab, India	168	96	57					3¾	
Miocene(?) to Pliocene(?)	1885	(?)*Tetralophodon* (*Lydekkeria*) *sinensis* type, M^3, Yun-nan, China									5
Pliocene	1932	*Tetralophodon bumiajuensis* type, M^3-M_3, Bumiaju, central Java				M^3 M_3	170 180	 70c	 39c		5¼ 5½

PROGRESSIVE M 3 (COMPARE FIGS. 308, 329).—This important table shows that M 3 is a very progressive tooth in the genus *Tetralophodon*, it remains relatively long and narrow, the average index of M_3 being 38 as compared with the average index 42.7 in known species of *Trilophodon*. The incipient, small pro-protolophid crest

[1]See footnote on page 349.

rises from $\frac{1}{2}$, $\frac{3}{4}$, to 1; the posterior crest rises from $\frac{1}{2}$, $\frac{1}{2}+$, $\frac{3}{4}$, to 1. This long narrow M 3 in both *Trilophodon* and *Tetralophodon*, correlated with the final concentration of the whole masticating function of the food on the posterior molars, M^3-M_3, together with the corresponding complication and evolution from brachyodonty to full hypsodonty of the crown in *Morrillia*, enables us to distinguish the posterior teeth of these Tetralophodonts from the corresponding molars in the phyla Serridentinæ, Rhynchorostrinæ, and Brevirostrinæ, although in some Brevirostrine species the third molars also become remarkably elongate and hypsodont.

Ridge-crest Enumeration.—It is very important to observe closely the gradual upgrowth of the *anterior* as well as of the *posterior* ridge-crests in these Bunomastodontidæ, as in the Stegodontinæ. New ridge-crests arise from *paired cones* which become *paired conelets;* these cones subdivide into two cones on each side; this makes *four* conelets in each fully completed transverse crest, whereas there are only two cones in each rudimentary crest.

Origin of the Tetralophodonts.—These medilongirostral mastodonts arose independently from an ancestral Oligocene stage which might be comprised within the genus *Phiomia*. This stage was less specialized than *Phiomia osborni*, which leads directly into *Amebelodon fricki*. Among the true ancestors of the *Tetralophodon* phylum the jaw remained medilongirostral, as in primitive species of *Phiomia;* the trefoils gradually began to double, as seen in the Middle Pliocene *T. falconeri;* a fourth crest arose on the 'intermediate molars,' unlike any species of *Trilophodon;* as in *Trilophodon* the entire function of mastication finally concentrated on the third superior and inferior molars; while in *Trilophodon* these posterior molars remained brachyodont, in the *Tetralophodon* phylum they finally became hypsodont (*Morrillia*). Consequently the distinctions between the genus *Trilophodon*, the typical genus *Tetralophodon*, and the subgenus *Morrillia* are *entirely in progressive characters* which developed throughout Miocene to Pleistocene times.

Phylum Tetralophodon

Jaws of medium length (medilongirostral)

Subgenus *Lydekkeria* doubtful Miocene and Pliocene Genotype: *Mastodon* (*Trilophodon*) *falconeri* Lydekker	Typical Genus *Tetralophodon* Lower Pliocene Genotype: *Mastodon longirostris* Kaup	Subgenus *Morrillia* Middle Pleistocene Genotype: *Tetralophodon barbouri* Osborn
M 3 slowly progressive.	M 3 rapidly progressive.	M 3 highly progressive.
Second superior and inferior molars subtetralophodont to tetralophodont; molars with single central trefoils and rudiments of double trefoils.	Second superior and inferior molars fully tetralophodont; molars incipiently doubling central trefoils.	'Intermediate molars' fully tetralophodont; pronounced double trefoils.
Third superior and inferior molars tetralophodont; tetartolophid incipient.	Third superior and inferior molars with 5½ to 6 crests.	Ridge-crests 7½ to 8⅓ in M^3.
Molars primitive, brachyodont.	Crowns of grinding teeth brachyodont (*T. longirostris*, *T. punjabiensis*), subhypsodont (*T. campester*, *T. elegans*).	Molars hypsodont; cement.
Tetralophodon (*Lydekkeria*) *falconeri*, Dhok Pathan, Punjab, India, Middle Pliocene. (?)*Tetralophodon* (*Lydekkeria*) *sinensis*, Mio-Pliocene, Yun-nan, China.	*Tetralophodon longirostris*, Eppelsheim, Germany; *Tetralophodon grandincisivus*, Maragha. Persia; *Tetralophodon punjabiensis*, India; *Tetralophodon campester*, Kansas; *Tetralophodon elegans*, Kansas; *Tetralophodon fricki* sp. nov., Texas.	*Tetralophodon* (*Morrillia*) *barbouri*, Nebraska. *Tetralophodon precampester* [= *Tetralophodon* (*Morrillia*) *barbouri* syn.]

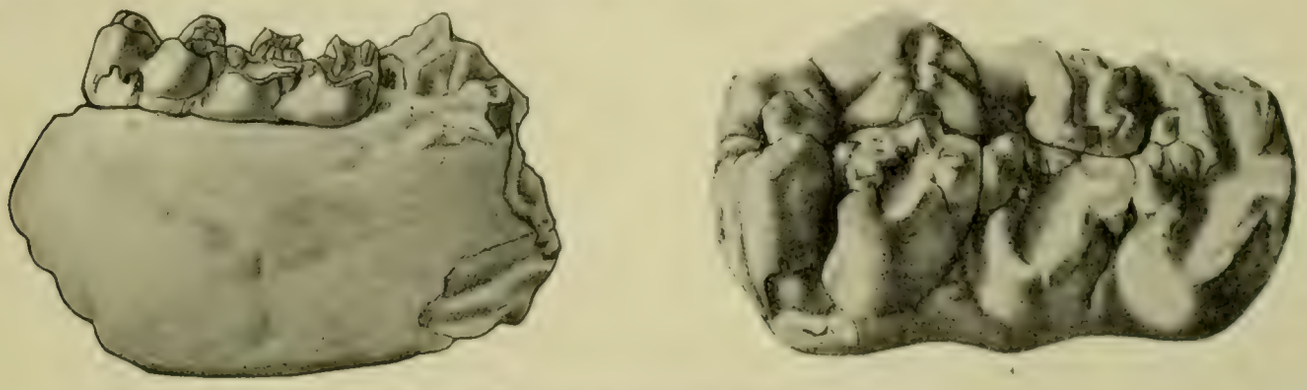
4. PROBABLE ORIGIN OF TETRALOPHODON. CHARACTERS OF THE PRIMITIVE SUBGENUS LYDEKKERIA, AS KNOWN IN THE PLIOCENE OF INDIA AND IN THE MIOCENE OR PLIOCENE OF CHINA

SUBGENUS: **LYDEKKERIA**[1] Osborn, 1924 [=**?TETRALOPHODON** Falconer, 1847, 1857]

Original reference: Amer. Mus. Novitates, No. 154, 1924, pp. 2, 3 (Osborn, 1924.634).
Genotypic species: *Mastodon (Trilophodon) falconeri* Lydekker, 1877.

SUBGENERIC CHARACTERS.—Single infero-external trefoils in third lower molars. 'Intermediate molars' with three and a half to three and three-fourths to four transverse ridge-crests; third lower molars probably four to five crested. Mio-Pliocene Tetralophodonts more primitive than *Tetralophodon longirostris*.

This primitive Pliocene stage of India appears to be ancestral to the true Lower Pliocene *Tetralophodon*. Like *Trilophodon* it has single central trefoils; unlike *Trilophodon* the second molar, M_2, exhibits three and a half to three and three-quarters to four transverse crests, thus passing into the *Tetralophodon longirostris* stage, in which the second molar has four crests. Inasmuch as Lydekker was the first to describe this animal and made great contributions to the fossil fauna of the Siwaliks, *Mastodon (Trilophodon) falconeri* was taken (Osborn, 1924.634, p. 2) as the genotypic species of the new subgenus *Lydekkeria*, named in Lydekker's honor and representing the Mio-Pliocene[1] evolutionary ancestral stage of the true Pliocene *Tetralophodon*.



TYPE OF TETRALOPHODON (LYDEKKERIA) FALCONERI

Fig. 309. Type of *Mastodon (Trilophodon) Falconeri* Lydekker, 1877. After Lydekker, 1880, Pl. XXXIII, figs. 1 and 4. Fig. 1. "Part of right ramus of mandible, with second true molar [r. M_2]: from the Punjab." Reduced to one-fourth natural size. Fig. 4. "Second right lower true molar: from the jaw represented in fig. 1." Reduced to one-half natural size. Dhok Pathan horizon, Punjab, India, Middle Pliocene. (Cf. Lydekker, 1885, p. 103): Ind. Mus. Calcutta "A.29. Part of right ramus of the mandible with m.2.; from the Potwár district, Punjab. Figured in the 'Pal. Ind.' *op. cit.* vol. i., pl. XXXIII., figs. 1, 4. This specimen is the type. *Collected by Mr. Theobald.*"

Hopwood (letter, Feb. 10, 1932) states that the holotype of *Lydekkeria* was collected by Theobald, not in the Middle Miocene Lower Chinji[2] horizon as described by Lydekker (1877), Pilgrim (1922–1927), and Osborn in the paragraphs below, but in the *Middle Pliocene* Dhok Pathan horizon of the Potwár district. Hopwood accordingly alters both the geologic age and the phylogenetic interpretation of Osborn. Therefore *Tetralophodon (Lydekkeria) falconeri* Lyd., 1877, is not in a Middle Miocene but in a Middle Pliocene stage contemporaneous with the *Mastodon* [*Tetralophodon*] *punjabiensis* Lyd., 1886. If Hopwood is right, *Lydekkeria* may become a synonym of *Tetralophodon*, and *M.* [*Tetralophodon*] *punjabiensis* Lyd., 1886, may become a synonym of *M.* [*Tetralophodon*] *falconeri* Lyd., 1877. Pilgrim (1913, p. 316) refers to specimens of *T. falconeri* occurring in the Middle Miocene, base of the Siwaliks.

[1]See notes above (p. 343) as to the doubtful generic validity and geologic horizon of *Lydekkeria*.
[2]The Lower Chinji is now regarded (1935) as of Mio-Pliocene age (see Fig. 413, p. 448).

Tetralophodon (Lydekkeria) falconeri Lydekker, 1877

Figures 309, 310

Type: Dhok Pathan horizon, Potwár district, Punjab, India, Middle Pliocene.

Compare *Tetralophodon grandincisivus.*

History.—This species is founded upon a very characteristic Middle Pliocene type from the Dhok Pathan horizon, Potwár district, Punjab, India, originally described by Lydekker, 1877, as *Mastodon (Trilophodon) Falconeri*, but subsequently regarded (Osborn) as possibly ancestral to *Tetralophodon longirostris.* It certainly does not belong, as regarded by Pilgrim, in the *Trilophodon angustidens* phylum, because its three and three-quarters crested second inferior molars, M_2, entirely remove it from the typical Trilophodonts. Pilgrim also refers to *T. falconeri* specimens found in the Manchhar beds, base of the Siwaliks, Middle Miocene (see Middle Miocene, Fig. 414).[1]

Type Level.—The geologic level of the type (Fig. 309) is very important. Lydekker (1885, p. 103) designated the type as from the Potwár district, Punjab. Pilgrim (1921–1927) confirmed the type as occurring in the Lower Chinji[2] horizon, Middle Miocene; Hopwood considers it of Middle Pliocene, Dhok Pathan age.

Phyletic Stage.—The species designated by Lydekker in 1877 as *Mastodon (Trilophodon) falconeri* was supposed to be of the same (Middle Miocene)[3] geologic age as the type of *Trilophodon angustidens* from Simorre; it cannot, however, be a relative of the *T. angustidens* phylum in which the intermediate molars are trilophodont. In other words, the three and three-quarters crested second inferior molars of *T. falconeri* remove it from the typical Trilophodonts in which M^2-M_2 remain trilophodont to the end. Lydekker states (1886.1, p. 40): "This species is of very large size, and apparently has a short and incisor-less mandibular symphysis." Nevertheless it seems best to place it in the genus *Tetralophodon*, for the absence of lower tusks may be a female character; see note on *T. punjabiensis* below.

Mastodon (Trilophodon) Falconeri Lydekker, 1877. "Notices of New or Rare Mammals from the Siwaliks." Rec. Geol. Surv. India, Vol. X, Pt. II, pp. 76–83. Type.—(Lydekker, 1880, Pl. xxxiii, figs. 1 and 4): "Part of right ramus of mandible, with second true molar [r.M_2]: from the Punjab." (Ind. Mus. A.29). Horizon and Locality.—Middle Pliocene, Dhok Pathan horizon, Potwár district, Punjab, India. Type Figure.—Lydekker, 1880, Pl. xxxiii, figs. 1 and 4.

Type Description.—(Lydekker, 1877, p. 83): . . . "this species is known by two lower molar teeth, one of which is the last milk-molar, and the other is the penultimate true molar. . . . Each of these teeth carries three transverse ridges and a fore and aft talon; . . . Both the present specimens belong to the wide-toothed *Mastodons;* the ridges are divided by an antero-posterior median valley; the first two pairs of columns are placed in the same transverse line, but the third pair are placed somewhat unsymmetrically; . . . The length of the larger specimen is 6.8 inches, and its breadth 3.7 inches; the length of the last milk-molar is 4.1 inches, and its breadth 2.4 inches. . . . I should propose to call the present species by the name of *Mastodon (Trilophodon) Falconeri* in honor of the describer of the many other forms of extinct Indian Proboscidia."

Osborn, 1922: Lydekker's original description [of Dp_4, M_2] quoted above does not agree fully with his subsequent designation of the type (1885, p. 103) cited in full in the legend of figure 309 above. Nevertheless we are compelled to accept the author's own selection of a tooth which he describes as follows:

(Lydekker, 1880, p. 206): "*Second lower true molar.*—Continuing our serial survey of the lower molars we come to the large specimen represented in fig. 4 of Plate xxxiii. This tooth is implanted in a fragment of the right ramus of the mandible, represented on a smaller scale in fig. 1 of the same plate; in front of the figured tooth there is in the jaw a fragment of another much worn tooth, which is too imperfect for description; the jaw was collected by Mr. Theobald in the Punjab. The figured specimen carries three stout transverse ridges and a very large hind-talon, and is slightly narrower in front than behind. From its great size, and from the number of its ridges, it is quite evident that this tooth must be the second lower true molar, and that it consequently corresponds in serial position to the upper molar represented in fig. 1 of Plate xxxii; the two teeth, however, belong to opposite sides. The lower molar is considerably more worn down than the upper, since in the former large dentine islets are exposed on the third ridge, whereas in the latter, the enamel of that ridge is not perforated."

Referred Molars of Tetralophodon (Lydekkeria) (?)falconeri

Fig. 310. Superior molar teeth of the left side, l.M^2, l.M^3, erroneously referred by Falconer to '*Mastodon sivalensis.*' Original formerly in Museum of Asiatic Society of Bengal; cast, Ind. Mus. A.102 and Brit. Mus. M.2881; from the Siwalik Hills, India, no horizon given. Figure after Falconer and Cautley, 1846 [1847], Pl. xxxiv, fig. 1, one-third natural size; also described as *M. sivalensis* (*fide* Falconer, 1867, p. 45), portion of skull showing palate with two molars on either side; tusk-sheaths very divergent; molars said to resemble *M. arvernensis* and *M. sivalensis.*

The skull and the teeth may belong to *Tetralophodon.* M^2 is inferior in size to the type M_2 of *Tetralophodon (Lydekkeria) falconeri* (Fig. 309); it appears to be in a somewhat similar stage of evolution; relative dimensions, type M_2 (Fig. 309), ap. 168 mm., tr. 96 mm., index 57, referred M^3 (this figure), ap. 165 mm., tr. 75 mm., index 45. See page 355, opposite.

Specific Characters.—(1) Lydekker (1886.1, p. 40) writes: "This species is of very large size, and apparently has a short and incisor-less mandibular symphysis; . . . The species may be a more specialized descendant from the *M. angustidens* stock. . . . Hab. India (Punjab and Sind)." (2) The characteristic points of the molars of *T. falconeri* may be summarized as follows: (Lydekker, 1880, p. 208) . . . "intermediate molars with three transverse ridges and large talons; ridges running directly across the crown of the tooth, and divided into inner and outer columns by an approximately mesial cleft; accessory columns [trefoils], situated on the inner side of this cleft in the upper, and on the

[1]Also in the Siwalik Collection from near Hasnot, India, Dhok Pathan horizon, two upper molars (Amer. Mus. 19838), an M^1 and M^2, are referable to *Tetralophodon falconeri*, the measurements and characters comparing closely with Lydekker's type (*fide* Colbert) See figure 413.

[2]See footnote on page 353.

[3]Now believed to be of Middle Pliocene age (see p. 353).

outer side in the lower molars, slightly blocking the middle of the transverse valleys; dentine islets of one column in each ridge trefoil-shaped . . . ; blunt tubercles at the inner extremities of the valleys in the upper, and at the outer in the lower molars; no cement." (3) Osborn, 1923: Thus the type tooth has single trefoils, as in the true trilophodont stage, and rudiments (Fig. 309) of double trefoils, but it has practically three and three-quarters *transverse crests*, as in a subtetralophodont stage; consequently it is intermediate in its ridge formula in the evolution of the second molar tooth between *Trilophodon* and *Tetralophodon* and probably ancestral to the latter. (4) Awaiting a fuller knowledge of this important stage, we are inclined to place this animal in the genus *Tetralophodon* and to regard it as a direct or collateral ancestor of the *T. longirostris* phylum.

Falconer and Cautley (1847), Falconer (1867).—Falconer and Cautley in 1846 [1847] figured (Pl. xxxiv, fig. 1) two superior grinding teeth with portion of a skull which in the plate descriptions are referred to *Mastodon* [*Pentalophodon*] *sivalensis* (Fig. 310 of the present Memoir).

Osborn, 1933: Despite the reference by Falconer of these two superior molar teeth, M^{2-3}, to a species which we now term *Pentalophodon sivalensis*, a member of the Brevirostrinæ, we observe that these teeth (Fig. 310) entirely lack the characters distinctive of the Brevirostrine subfamily which contains *Anancus* and *Pentalophodon*. The internal and external cones do not *alternate*, they are opposite each other; all the ridge-crests are simple, transverse, as in the Tetralophodontinæ. The ridge formula is $M\ 2^{4}\ M\ 3^{4\frac{1}{2}}$. These grinding teeth, therefore, correspond with the rather primitive species *Tetralophodon* (*Lydekkeria*) *falconeri*, much more primitive than *Tetralophodon punjabiensis* and not far distant in their evolutionary stage from *Tetralophodon* (*Lydekkeria*) *sinensis*.

The above description of the type (Fig. 309), as well as the ancestral relationships and geologic level, is subject to future revision. At present the subgenus *Lydekkeria* is doubtful.

Tetralophodon (Lydekkeria) sinensis Koken, 1885

Figure 311

Yun-nan, China, Mio–Pliocene.

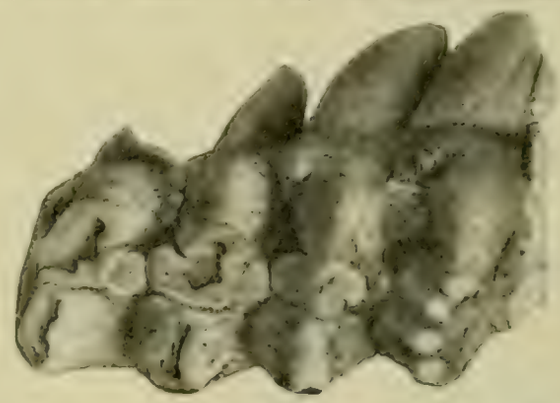
Geologic Locality.—The type of *Mastodon perimensis* var. *sinensis* Koken, 1885, is from Yun-nan, China, a province of vast size. Its geologic age is consequently uncertain. Its tetralophodont structure and single median trefoils, however, indicate that it is of Upper Miocene age. The tetartoloph (Fig. 311) is more strongly developed than in *T.* (*Lydekkeria*) *falconeri* (Fig. 309), but the rudimentary *double* trefoils of *T.* (*L.*) *falconeri* do not appear.

Mastodon perimensis var. *sinensis* Koken, 1885. "Ueber fossile Säugethiere aus China." Pal. Abhand., Band III, Heft 2, p. 34. Type.—Probably a third upper molar of the left side, $l.M^3$. Horizon and Locality.—Mio-Pliocene, Yun-nan, China. Type Figure.—*Op. cit.*, Taf. xii, fig. 1.

Type Description.—(*Op. cit.*, p. 34): "Der abgebildete Zahn wird von vier Querjochen zusammengesetzt; da sich aber am hinteren Ende der Ansatz zu einer fünften Schmelzerhebung findet, welche, wie die genaue Betrachtung der Bruchfläche lehrt, von einer wohl entwickelten Wurzel gestützt wurde, so ist die Annahme wohl gerechtfertigt, dass im Ganzen fünf Querjoche vorhanden waren."

Matthew and Granger (1923, p. 565) remark: "Koken in 1885 [Footnote: 'Koken, E. 1885. 'Fossile Saügethiere aus China.' Pal. Abh., III, Heft 2.'] described a collection secured by von Richthofen, apparently from the trading junks of the Yang-tse-kiang and understood by him to have come from far up the river in 'caves in Yun-nan.' Whether this was the real locality remains to be verified; one has the impression from the reading of von Richthofen's letter, quoted by Koken, that the traveller himself suspected that the locality might not have been correctly stated."

The five crested type of *Tetralophodon* (*Lydekkeria*) *sinensis* should be compared with the type of *Tetralophodon* (*Lydekkeria*) *falconeri*, Middle Pliocene of India, from which it differs in the presence of *single* trefoils, a character which inclines us to regard it as more ancient in dental development than the Lower Pliocene stage of *Tetralophodon longirostris*. In other respects the fractured type of *T. sinensis* agrees fairly well with the corresponding teeth, M^3, in the *referred* palate of *T. longirostris* (Fig. 315).



Tetralophodon (Lydekkeria) sinensis of Yun-nan, China

Fig. 311. Five crested type molar of *Mastodon perimensis* var. *sinensis* Koken, 1885, Taf. xii, fig. 1: "M^2 [error, $l.M^3$] des linken Unterkiefers." Yun-nan, China. Koken (*op. cit.*, p. 34) concludes: . . . "so ist die Annahme wohl gerechtfertigt, dass im Ganzen fünf Querjoche vorhanden waren."

Osborn, 1922: The type of the species *Mastodon perimensis* var. *sinensis* agrees fairly well with the third left superior molar, $l.M^3$, of *Tetralophodon longirostris*, as shown in figure 315, in which the trefoils appear only on the internal lophs and the tetartoloph is decidedly narrower than the tritoloph. Referring to the type figure (Fig. 311) and to the description by Koken below, we are inclined to regard this tooth as probably representing a third upper molar of the left side in the *Tetralophodon* stage of development. This opinion differs from that of Professor Koken in establishing this subspecies, who considers that the type (Fig. 311) represents a left M_2 of the lower jaw; if Osborn's determination is correct, the species is in the *Tetralophodon* stage of development of the intermediate molars, which would place it in the genus *Tetralophodon*.

Osborn, 1932: The above description and facsimile of the type figure leave us certain that this animal is related to the *Tetralophodon* phylum, rather than to the brevirostrine *Anancus* phylum, as suggested in Koken's specific term *perimensis* var. *sinensis;* the word *perimensis* must therefore be dropped and the species read simply *Tetralophodon* (*Lydekkeria*) *sinensis*. *It is clearly distinguished from T. longirostris* by the presence of single trefoils; it also differs from the type of *T. falconeri* in this character; nevertheless both these species, *T. falconeri* of India and *T. sinensis* of China, may be provisionally regarded as representing an ancestral stage of evolution in the *Tetralophodon* phylum.

5. CHARACTERS OF THE TYPICAL GENUS TETRALOPHODON OF FALCONER, INCLUDING SPECIES MIGRATING FROM EURASIA TO THE WEST CENTRAL UNITED STATES

TETRALOPHODONTINÆ van der Maarel, 1932

Maarel (1932, pp. 108–126) proposes the subfamily TETRALOPHODONTINÆ, to which he refers the four species *Tetralophodon (Lydekkeria) falconeri, T. (Lydekkeria) sinensis, T. punjabiensis, T. bumiajuensis.* This seems to be an excellent new term to distinguish the *Tetralophodon* phylum from the *Trilophodon* phylum and is adopted by Osborn.

GENUS: TETRALOPHODON Falconer, 1847, 1857

Genotypic species: *Mastodon longirostris* Kaup, 1832.
Syn.: *Tetrabelodon* Cope, 1884, not as defined by Cope but as used by other authors. In part, *Lydekkeria* Osborn, 1924, as defined by Osborn, doubtfully founded on genotype *Mastodon (Trilophodon) falconeri* [=*Tetralophodon (Lydekkeria) falconeri*] (*fide* Hopwood, letter, 1932). Includes *Morrillia*, progressive final stage.

GENERIC CHARACTERS.—Pliocene Tetralophodonts more progressive than *Lydekkeria*; trefoils doubling; lophs slowly elevating to a subhypsodont condition. Intermediate molars with four to four and a third transverse ridge-crests; third molars with five and a half to six ridge-crests (*T. punjabiensis, T. elegans, T. campester*), with eight ridge-crests (*T. (Mor.) barbouri*). Inferior and superior valleys with *central conules* (*T. fricki, T. punjabiensis*), reduced or lacking (*T. longirostris*). Enamel band on superior incisors only.[1]

This genus, based on the genotypic species *Mastodon longirostris* Kaup, also includes a very large animal of similar geologic age, namely, *Mastodon grandincisivus* Schlesinger, 1917, of the Lower(?) Pliocene of Maragha, Persia, an animal in which the grinding teeth are in a relatively primitive condition (Fig. 321), with incipient double trefoils; also the Middle Pliocene *Mastodon punjabiensis* Lydekker, 1886, from the Dhok Pathan horizon, Siwalik Hills, India.

It appears probable that in Lower Pliocene time the Tetralophodonts migrated into North America, because the species *Tetralophodon punjabiensis* of the Dhok Pathan of India, Middle Pliocene stage, seems to be the last of this race in Asia. An early Tetralophodont to appear in America was *Tetralophodon fricki* of Lower to Middle Pliocene time. Also, as shown in the diagram (Fig. 308), all the American species of *Tetralophodon* are much more *hypsodont* than the European. Accordingly the less progressive American species, *T. fricki*, appears to lead into the somewhat more progressive *T. campester*, which, in turn, leads into *T. elegans* (Fig. 329), and finally into the new subgeneric stage *Tetralophodon (Morrillia) barbouri.*

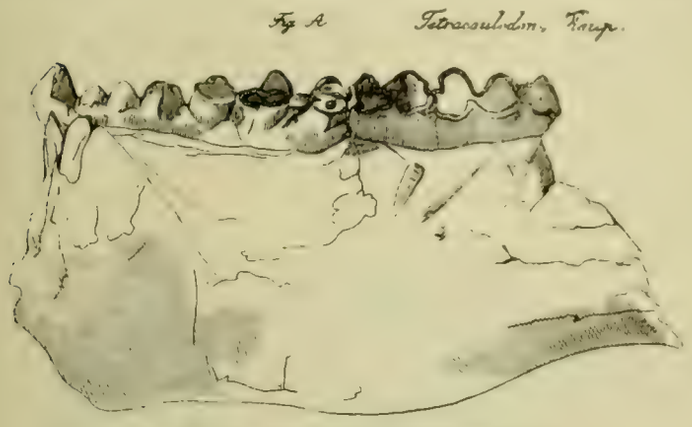
Hopwood (letter, Feb. 10, 1932) states that the genotypic species of *Lydekkeria*, i.e., *Tetralophodon (Lydekkeria) falconeri* Lyd., 1877, is of the same geologic age (Dhok Pathan, Middle Pliocene) as *Mastodon* [=*Tetralophodon*] *punjabiensis* Lyd., 1886, and thus *T. falconeri* Osb. may be a contemporary of *T. punjabiensis* Lyd.

6. EURASIATIC SPECIES OF TETRALOPHODON, CHIEFLY LOWER PLIOCENE, NAMELY, T. LONGIROSTRIS, T. GRANDINCISIVUS, AND T. PUNJABIENSIS

Only four well-defined Mio-Pliocene Eurasiatic species have been discovered, exhibiting the following characters: (1) In all of these the grinding teeth are simple, *short crowned* or *brachyodont;* (2) the *fourth* crests of the 'intermediate molars' are still in formation; (3) the double trefoils are rudimentary or in process of formation; (4) in the third grinders the number of crests is limited to 5½ to 6; (5) the second grinders are long in use (Figs. 313, 315) but begin to disappear in the adult stage (Fig. 320); (6) the jaws are medilongirostral (Figs. 313, 320); (7) the inferior and superior incisors are straight (Fig. 320); (8) the posterior grinding teeth may readily be distinguished from the 4 to 4½ to 5+ crested grinders of *Trilophodon* by the more numerous crests. A synopsis of the known species is as follows:

[1] An *inferior enamel band* is observed (Fig. 317) by Schlesinger in his type of *Mastodon (Bunolophodon) grandincisivus;* this is exceptional.

Tetralophodon (*Lydekkeria*) *falconeri*, Middle Pliocene of India	*Tetralophodon grandincisivus*, Lower (?) Pliocene, Maragha, Persia	*Tetralophodon longirostris*, Lower Pliocene of Eppelsheim	*Tetralophodon punjabiensis*, Middle Pliocene, Dhok Pathan, Siwaliks, India
Primitive characters as enumerated above.	Second molars somewhat reduced.	Both grinding teeth in use.	
Third molars not certainly known. See, however, figure 310, 4–5 crested M^3.	Third superior and inferior molars 5½ crested (Figs. 318, 321).	M2 fully 4 crested; M3 with 5½ crests.	Third inferior molars with 5½ crests.
Double trefoils incipient.	Double trefoils not developed.	Double trefoils rudimentary.	Double trefoils rudimentary.
Very primitive.	Inferior tusks, enamel band.	Somewhat progressive.	Somewhat progressive.



TYPE OF TETRALOPHODON LONGIROSTRIS KAUP

Fig. 312. Original type figure of *Tetracaulodon longirostre* Kaup, 1832, Taf. XI, fig. *A*, M_2-M_3, from Eppelsheim, one-fifth natural size. Original in Darmstadt Museum; cast Amer. Mus. Warren Coll. 10465. Compare figure 313.

Tetralophodon longirostris Kaup, 1832

Figures 181, 196, 308A, 312–316, 319, 329A, 331, 338

Lower Pliocene of Eppelsheim, Germany.

Syn.: *Tetracaulodon longirostre* Kaup, *Mastodon dubius* Kaup and Scholl, *Mastodon grandis* Kaup and Scholl, of Eppelsheim.

As shown above in comparative figure 308, the Lower Pliocene Eppelsheim *Tetralophodon longirostris* type molar (A) is far more primitively brachyodont than any of the American Pliocene Tetralophodonts (B, D, E, F).

HISTORY.—This classic type was first described by Kaup in 1832 as belonging to *Tetracaulodon* (i.e., *Mastodon*) *angustidens* as follows:

(Kaup, 1832.2, p. 628): "Ueber zwei Fragmente eines Unterkiefers von *Mastodon angustidens* Cuv., nach welchen diese Art in die Gattung *Tetracaulodon* Godmann gehört, von J. Kaup, Taf. XI. . . . Im November [Footnote: 'Etwas später schreibt mir nun Professor Dr. Schinz: in den Gruben von Elgg kommt *Tetracaulodon*, nahe verwandt mit Mastodon, vor. . . . Es ist mir wahrscheinlich, dass es ebenfalls *Tetracaulodon longirostre* (*Mast. angustidens*) ist.'] dieses Jahres erhielt das Darmstädter Museum aus der Kiesgrube von Eppelsheim zwei Fragmente eines Unterkiefers, von welchen das hintere zwei Backenzähne, das vordere zwei Alveolen für Stosszähne enthält. Nach den Backenzähnen gehört dieser Kiefer *Mastodon angustidens* an, das nach den Alveolen des vorderen Stücks in die Gattung *Tetracaulodon* zu verweisen ist."

(Kaup, 1835, p. 65): "J'ai décrit plus tard dans l'*Isis* [Footnote: 'Isis 1832 pag. 628 pl. XI.'] deux fragments d'une mâchoire inférieure avec deux défenses, et je les ai donnés encore au *M. angustidens* en le plaçant dans le genre *Tetracaulodon;* puis j'ai changé le nom d'*angustidens* en *T. longirostris*, et plus tard encore j'ai regardé le *M. arvernensis* comme synonime du *M. angustidens*."

TYPE FIGURE.—Kaup's type figure is reproduced in facsimile herewith (Fig. 312). The same type jaw, a portion of a right mandible containing r.M_{2-3}, with the front part added, appears beneath a *referred* skull in Kaup's Atlas of 1835 (1835, Tab. XIX, fig. 1), cast Amer. Mus. Warren Coll. 10465. This type jaw and referred skull (Fig. 313) appear again as a beautiful wood engraving in Richard Owen's "British Fossil Mammals" of 1846, p. 271, fig. 96;

Upper and lower jaws of the *Mastodon angustidens*, from Epplesheim, after Kaup.

Fig. 313. Kaup's composition of the referred skull and type jaws of '*Mastodon*' *longirostris* from Eppelsheim, one-ninth natural size. After Owen's "British Fossil Mammals," 1846, p. 271, fig. 96, *Mastodon angustidens*. The skull is the same as that represented in figure 315. The lower jaw is identical with that figured by Kaup as the type of *Tetracaulodon longirostre* (Kaup, 1832.2, Pl. XI, fig. *A*), reversed and restored by the addition of the anterior portion of the ramus (see Tab. XIX, fig. 1). Cast Amer. Mus. Warren Coll. 10470 (skull); also cast Amer. Mus. Warren Coll. 10465 (jaw).

our figure 313 is a facsimile reproduction of Owen's figure. It is significant that at this time Owen ignored Kaup's specific name *longirostris* and referred this classic specimen to Cuvier's species *Mastodon angustidens*. Thus it was a long time before the real and profound specific and generic separation of Kaup's type (of the Lower Pliocene of Eppelsheim) from Cuvier's type (of the Middle Miocene of Simorre) was recognized. We probably owe to Falconer, 1868, the first clear recognition of the *tetralophodont* stage of the intermediate molars.

SYNONYMS OF T. LONGIROSTRIS.—In the meantime Kaup discovered in Eppelsheim a beautifully preserved and unworn third upper molar tooth of the right side which he (Kaup and Scholl,

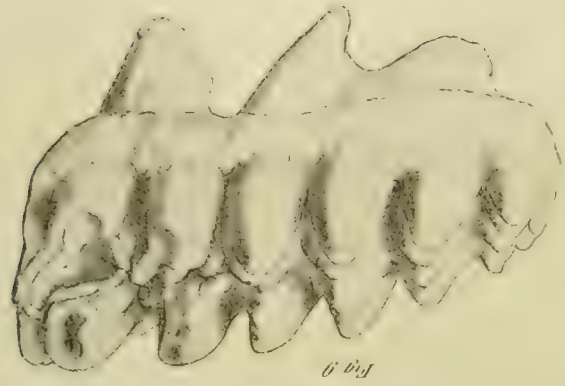


Fig. 314. Type r.M^3 of *Mastodon grandis* Kaup and Scholl, 1834. After Kaup, 1835, Pl. XVIII, fig. 9, one-half natural size, reduced to one-third natural size in the present Memoir. From Eppelsheim, Germany. Original in Darmstadt Museum; cast Darmstadt Mus. 161, Amer. Mus. 10481. Diameters 224×98.

A third right upper molar, probably of a large male, of *Tetralophodon longirostris*. Five and a half crests and a very rudimentary hexalophid. Observe *double trefoils* on proto- and metalophs, quadruple conelets on hexaloph. Molar reversed to show natural position.

1834) made the type of a new species *Mastodon grandis*, Kaup's type figure of 1835 being reproduced in facsimile herewith (Fig. 314). Kaup also described another specimen which he (Kaup and Scholl, 1834) named *Mastodon dubius*, a last upper molar, M^3, ap. 144 mm., tr. 69 mm. (cast Darmstadt Mus. 178) and figured in 1835, Tab. XVIII, fig. 1. Subsequently he recognized that both *M. grandis* and *M. dubius* belonged to his previously named species *Mastodon longirostris*.

Of these specimens Kaup (1835, p. 77) remarks: "J'ai fait cette distinction dans la seconde édition de mon Catalogue des plâtres, et j'ai donné le nom de *Mastodon dubius* à celui dont les dents étaient plus petites et dont la molaire inférieure correspondait avec ces dents, et de *Mastodon grandis* à celui qui avait les dents de fig. 9. avec les correspondantes." The latter is a third upper molar, M^3, of a large male example of *T. longirostris*, and this specimen is figured by Kaup himself (1835) on Pl. XVIII, fig. 9, as *M. longirostris*.

Referred Specimens.—Besides these two synonymous type specimens, Kaup in his important work of 1835 reproduced a beautiful figure of a referred palate and superior dentition together with an elongated and edentulous rostrum. In the facsimile reproduction of this palate (Fig. 315) the rostrum is omitted; its palatal aspect should be taken from Kaup's original plate (1835, Pl. XVI, fig. 5). The same palate and rostrum form the basis of Kaup's restoration of the skull (Fig. 313) as reproduced from Owen.

Generic Characters (Genotype Mastodon longirostris).—The generic characters deduced from these specimens of *Tetralophodon longirostris* are the following:

Adult dental formula: I^2-I_2, M^1-M_1 (juv.), M^2-M_2, M^3-M_3. The adult dentition in functional use consists of the second upper and lower incisors and of the second and third upper and lower molars, or six teeth in all; fourth milk premolars (see Fig. 304 = 4½ ridge-crests) also second upper and lower 'intermediate molars' with four transverse crests; upper and lower molars with internal and external trefoils more or less fully developed.

Specific Characters of T. longirostris.—The tetartoloph in M^2 is narrower than the tritoloph. M^3 presents five and a half lophs, each loph being divided by a median fissure; trefoils strongly developed at the median base of the inner cones and less strongly developed at the median base of the outer cones. The third lower molars are also five and a half crested with the trefoils more strongly developed at the median base of the outer cones; each of the four anterior transverse crests terminates in four conelets, except the posterior half-crest which terminates in two conelets. The specific measurements and proportions are given on the following page.

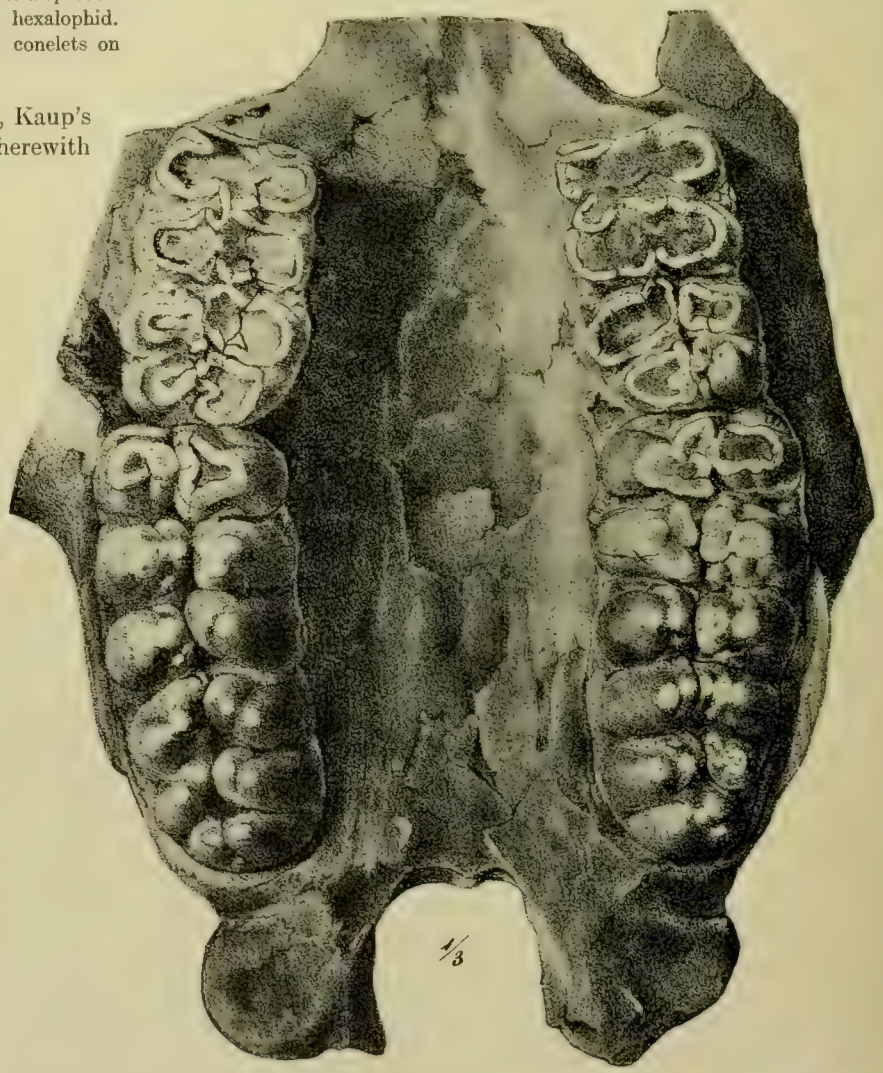


Fig. 315. Kaup's original figure of *referred* palate and superior dentition of '*Mastodon*' *longirostris* Kaup, one-third natural size. After Kaup, 1835, Pl. XVI, fig. 5. Cast Amer. Mus. 10470. Observe *double* conelets on hexaloph.

In reproducing this referred palate, the anterior part of the skull, as represented by Kaup, has been cut off. This is the same specimen as the skull which is reproduced in lateral view in figure 313, namely, after Kaup, 1835, Pl. XIX, fig. 1, and Owen, 1846, fig. 96.

		ap.	tr.	I.		ap.	tr.	I.
Referred palate of *T. longirostris*	M^2	123	81	66	M^3	196	89	45
Type lower molars of *T. longirostris*	M_2	138	67	49	M_3	189	70	37
Type of *Mastodon grandis*	M_2	....	....	....	M^3	224	98	44

The observations and measurements of the type and referred teeth may be verified from excellent casts in the British Museum and in the American Museum (Amer. Mus. 10465 and 10470). *campester* of the Lower Pliocene of Kansas. In figure 331 we reproduce side by side, to the same scale, the type of *Tetralophodon longirostris* and the type of *T. campester*.

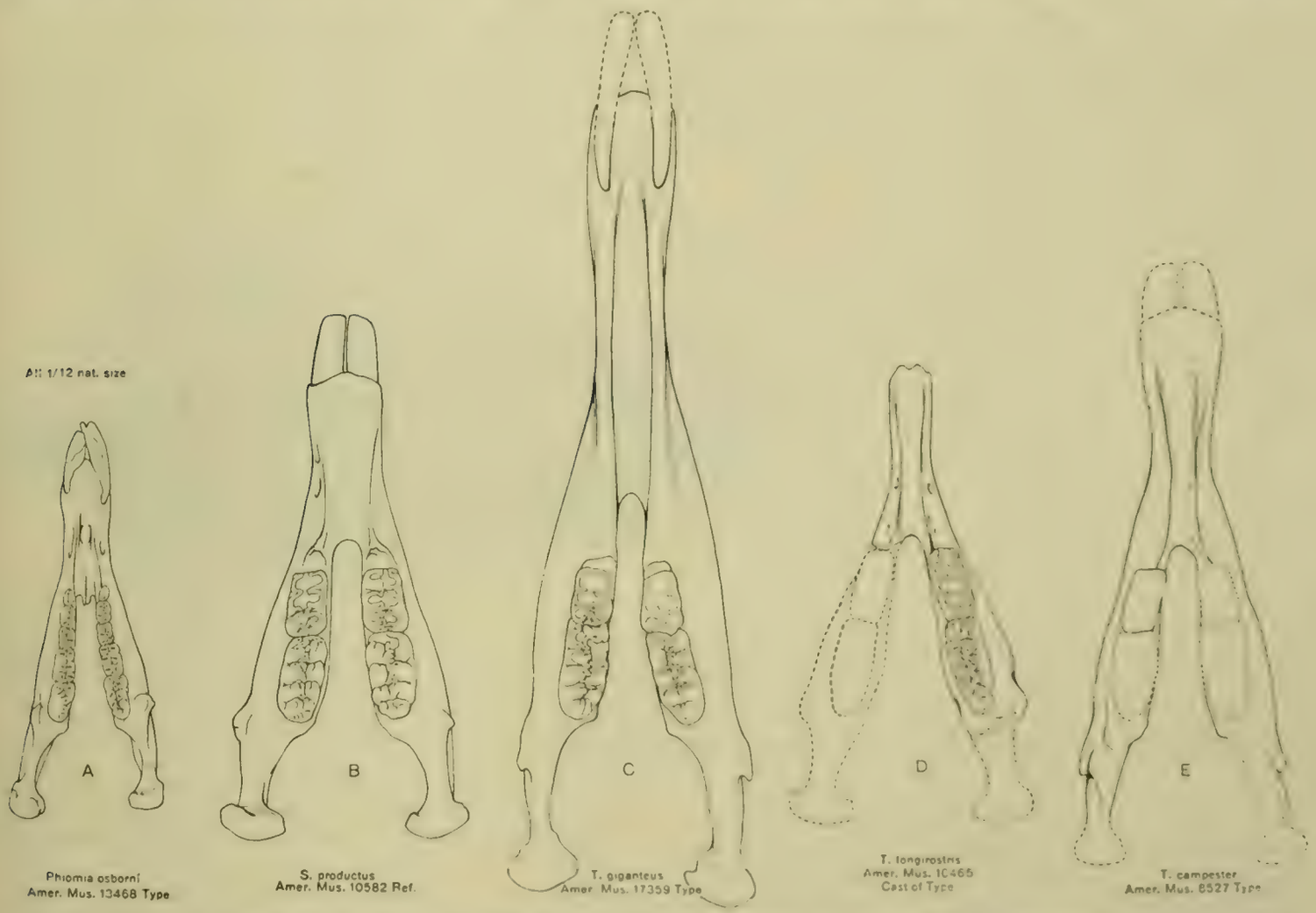


Fig. 316. Kaup's type jaw (D) of *Tetralophodon longirostris* compared with *Phiomia* (A), *Serridentinus* (B), *Trilophodon* (C), and *Tetralophodon campester* (E). All to the same scale of one-twelfth natural size.

Genus		Species
Tetralophodon	Medilongirostrine.	D, *Tetralophodon longirostris* type jaw (after cast Amer. Mus. 10465).
Tetralophodon	Medilongirostrine.	E, *Tetralophodon campester* type jaw (Amer. Mus. Cope Coll. 8527)
Trilophodon	Hyperlongirostrine.	C, *Trilophodon giganteus* type jaw (Amer. Mus. 17359).
Serridentinus	Medilongirostrine.	B, *Serridentinus productus* ref. (Amer. Mus. 10582).
Phiomia	Medilongirostrine.	A, *Phiomia osborni* type jaw (Amer. Mus. 13468).

It is very important that we compare this classic species in detail with some of the related forms, such as *Tetralophodon grandincisivus* of the Lower Pliocene of Maragha, Persia, which seems to be somewhat more primitive than *T. longirostris;* or with *Tetralophodon falconeri* of the Middle Pliocene of India, which also seems to be more primitive; or with the more progressive species *Tetralophodon*

Medilongirostral Jaw Structure.—A third reason given above why *Tetralophodon longirostris* cannot be considered a descendant of the true *Trilophodon angustidens* phylum is that while Kaup was so much impressed with its length of jaw that he gave it the specific name *longirostris*, it is none the less *medilongirostral* when compared with members of the subfamily Longirostrinæ. Its

actual inferiority in size and in length of jaw is well illustrated in comparative figure 316 above.

The principle of adaptive radiation to different habitats and modes of feeding seems to be at work in producing these medilongirostral and hyperlongirostral forms of jaw. It was possible for the *Trilophodon giganteus* jaw to reach the ground and to serve in uprooting tubers and other plants; it does not seem possible that the *Tetralophodon longirostris* jaw reached the ground. By way of compensation, however, the grinding teeth of *Tetralophodon* contain more crests within the same linear space and are more complicated in coronal pattern. Combining M_2, M_3, we count seven and a half to eight crests with single trefoils in *Trilophodon giganteus;* in the same linear space, we count ten full crests in *Tetralophodon longirostris,* with double trefoils. This superior complex molar structure may compensate for the abbreviation of the jaw of *T. longirostris.*

Medilongirostrines (W. D. Matthew, September, 1920; Munich Museum).—In the Munich Museum is a very large tetralophodont mastodon with four crested M_2 from the Upper (?) Miocene, Schönnbrunn, Oberbayern. Four very distinct crests and a small heel on M_2, five crests on M_3; trefoils well marked; front of jaw and lower tusks just as in *M.* [=*Turicius*] *turicensis.* It is labeled *M. turicensis,* but is more probably *Tetralophodon longirostris.* [This specimen, mistakenly labeled "*M. turicensis,*" belongs in the Tetralophodontinæ. H. F. O.]

Schlesinger, 1922, pp. 44–60.—The student of *Tetralophodon longirostris* is referred to Schlesinger's description of a young individual from the Upper Pontian bone beds of Baltavár, Hungary, displaying the milk dentition (*op. cit.*, 1922, Taf. viii, fig. 7), of a second lower molar, r.M_2 (Taf. viii, fig. 5), also of a tetralophodont first lower molar, l.M_1 (Taf. viii, fig. 9).

In his detailed description of this Lower Pliocene species (*T. longirostris*), as represented in the Vienna and Budapest collections, Schlesinger (1922, p. 44) treats this animal as a descendant of '*Mastodon angustidens,*' e.g., Mastodon $\frac{\text{angustidens Cuvier,}}{\text{longirostris Kaup}}$ and as ancestral to various transition forms to '*M. arvernensis,*' e.g., Mastodon $\frac{\text{longirostris Kaup}}{\text{arvernensis Cr. and Job.}}$ This phylogenetic theory of Schlesinger is not accepted by Osborn in the present Memoir, because: (1) It is observed that *Trilophodon angustidens* belongs to the excessively long-jawed Longirostrinæ which terminate in the Upper Miocene and the Pliocene of America; (2) the medilongirostral *Tetralophodon longirostris* has its own descendants in the tetralophodont species of America; (3) the *Anancus arvernensis* springs not from *Tetralophodon longirostris* but from Mio-Pliocene ancestors in India, e.g., *Anancus properimensis.*

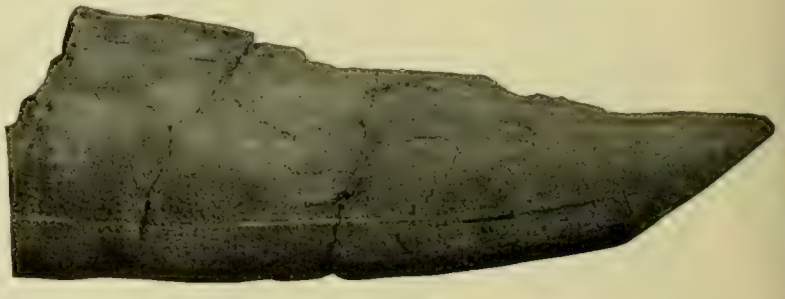
Tetralophodon grandincisivus Schlesinger, 1917

Figures 317, 318, 320, 321

Lower (?) Pliocene of Maragha, Persia, geologic age regarded as similar to that of Eppelsheim, Pikermi, and Samos.

Geologic Range.—This animal is more primitive than *Tetralophodon longirostris.* It appears from a brief study of this specific stage, very fully treated in Schlesinger's great memoir of 1922, pp. 217–219, also Taf. i, that the author regards the geologic range of this species as extending from the type locality of Maragha, Persia, on the east, to Austria and Hungary, on the west. It will be necessary before the species can be fully defined to secure more material from the type locality of Maragha.

Schlesinger, 1917–1922.—The discovery and description by Schlesinger of this important specimen greatly enriches our knowledge of the genus *Tetralophodon.* The type incisor (Fig. 317) from Persia and [paratype, Osborn] molar (Fig. 318) from Austria of this giant form indicate an affinity to the Medilongirostrines and the species may be provisionally termed *Tetralophodon grandincisivus.* As described by Schlesinger, the lower tusks are partly surrounded by enamel; the *paratype* third superior molars exhibit indications of the valleys being invaded by accessory trefoils which will become more apparent when worn. The five and a half crested M^3, supplemented by the six crested M_3 shown in Schlesinger's reconstruction (Fig. 320), leads us to expect that M^2-M_2 will prove to be four crested, hence in the *Tetralophodon* stage, as implied also by Schlesinger's comparison of this animal with *Tetralophodon longirostris.*



Type of Tetralophodon grandincisivus

Fig. 317. Extremity of type lower tusk of *Mastodon* (*Bunolophodon*) *grandincisivum* Schlesinger, 1917, left I_2, from the inner side. Type loc.: Maragha, Persia. Pliocene. Collection of Royal Museum of Vienna (Naturhistorische Staatsmuseum) No. XII.6, 1893. After photograph loaned by Doctor Schlesinger. Reproduced one-fourth natural size. Compare Schlesinger, 1917, Taf. xxxiv, fig. 1. Observe enamel and attrition.

Schlesinger's reconstruction of the skull and lower jaws (Fig. 320) represents an animal in an evolutionary stage which reminds us of both *Tetralophodon longirostris* and *T. campester,* as shown in our combined figure of these two types (Fig. 331).

Mastodon (*Bunolophodon*) *grandincisivum* Schlesinger, 1917. "Die Mastodonten des K. K. Naturhistorischen Hofmuseums." Denk. K. K. Naturhist. Hofmuseums, Band I, 1917, p. 119. Type.—A left inferior incisor, I_2, Taf. xxxiv, figs. 1 and 2, from Maragha, Persia. [Paratypes, Osborn] Two gigantic molars (M^2 right and M^3 left) from Mannersdorf near Angern, Austria, Taf. xv, figs. 1 and 2. Regarded as of Lower Pliocene age.

M. grandincisivus was a giant in the strictest sense, but inferior in size to *Deinotherium gigantissimum.* Schlesinger observes (1917, p. 227): "In unseren Breiten stand die Entwicklung mit *M. longirostre* nicht still. Aus den Übergangstypen von *M. angustidens* her hatte sich—offenbar im Unterpliozän—eine Form mit tetralophodonten, stark *longirostre*-ähnlichen Molaren abgespalten, die, im Gegensatze zur Entwicklungsrichtung des *M. longirostre,* die unteren Stosszähne zu einer mächtigen Schaufel entfaltete; *M. grandincisivum* n. sp. Es erreichte noch im Unterpliozän gigan-

tische Grösse und scheint seine Schwesterform auf ihrem Wanderwege zum Teil begleitet zu haben. Die bisher bekannten Fundpunkte, Niederösterreich, Ungarn und Persien (Maragha), deuten darauf hin."

Type and Paratype Characters.—It is important to observe that the specific name *grandincisivus* applies to the giant lower incisor tooth, as reproduced in figure 317. This tooth is beveled on its inferior surface at the extremity and the enamel band is apparently thickened or not conspicuous below. It is also important to observe that the paratype reproduced in figure 318 is not from Maragha but from Lower Austria; consequently there is considerable doubt whether the paratype belongs to the same specific stage as the type. Schlesinger, however, figures (1917, fig. 5) a juvenile skull from Maragha, in palatal view, which he refers to Mastodonten d. Hofmuseums (L.-V. [Literaturverzeichnis] 27) S. 119 ff. Taf. xxv u. xxxiv.'] auf Grund mehrerer Molaren und eines Inzisors neu aufgestellten *M. grandincisivus* an. Der Fund bildet ein Unikum der Sammlung der ungarischen geologischen Reichsanstalt und wurde in der Souheitlschen Ziegelei in Pestszentlörincz, südöstlich von Budapest, aus Tonen gehoben, welche der mittelpontischen Stufe (nach v. Halaváts) angehören. I. Lörenthey [Footnote: 'I. Lörenthey: Stratigraphie d. Tertiärbildungen v. Budapest. (L.-V. 20) S. 355.'] fasst sie als Basis seines oberen Pannonikums auf, [Footnote: 'Ich kann mich nicht entschliessen von der eingebürgerten Bezeichnung 'Pontische Stufe' abzugehen.'] das er entgegen Gy. v. Halaváts ungeteilt dem unteren(*Lyrcaca*-Horizont = pontische Stufe des Wiener Beckens) gegenüberstellt."

[Paratype Osborn] Left M^3 of Tetralophodon grandincisivus

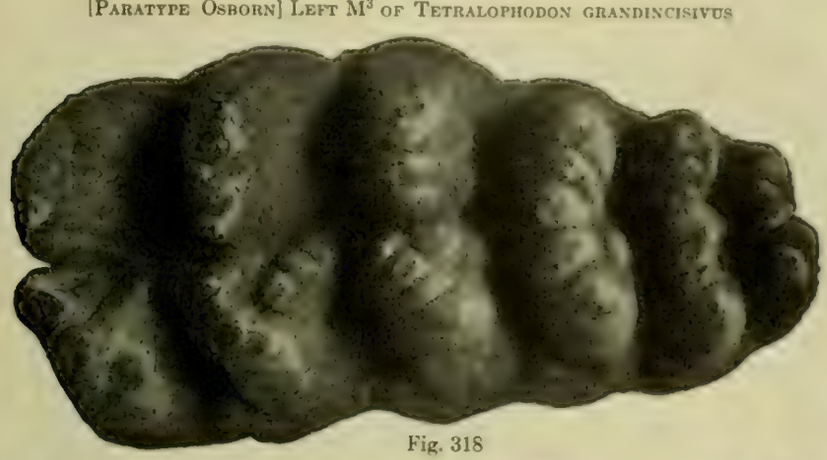


Fig. 318

Referred Tetralophodn longirostris

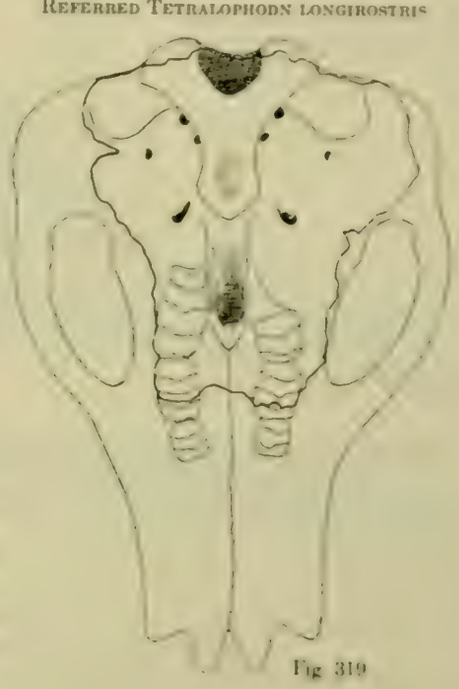


Fig. 319

Fig. 318. One of the [paratypes, Osborn] of *Mastodon grandincisivum* Schlesinger, M^3, left side. From Mannersdorf near Angern, Lower Austria. Collection of Royal Museum of Vienna (Naturhistorische Staatsmuseum). After photograph loaned by Doctor Schlesinger. Reproduced one-half natural size. Compare Schlesinger, 1917, Taf. xv, fig. 2. Observe multiple *conelets* on ridge-crests.

Fig. 319. Referred skull of young *Tetralophodon longirostris* from Maragha, Persia, described by Schlesinger, 1917, p. 80, fig. 5, as follows: "Schädel von *Mastodon* (*Bunolophodon*) *longirostre* Kaup (junges Tier). Ansicht von unten; rekonstruiert über dem Rest von Maragha. Die Fläche des Originals ist durch eine stärkere Grenzlinie gekennzeichnet. Horizont: Unteres Pliozän. Wiedergabe: ¼ natürl. Grösse."

Compare M^3 of *Tetralophodon punjabiensis* (Fig. 325, p. 365).

Mastodon longirostre, his figure being reproduced herewith (Fig. 319). This juvenile skull is difficult of specific reference but it tends to confirm the presence in Maragha of animals in the *Tetralophodon* stage.

Finally we are indebted to the same author (1922) for a reconstruction of the skull and jaws (Fig. 320) of the species *grandincisivus*, based on materials gathered from Pestszentlörincz, Hungary. In this reconstruction of *Mastodon* (*Bunolophodon*) *grandincisivus* the most marked distinction from the *Tetralophodon longirostris* stage is the fact that in the adult condition the grinding teeth are reduced to the third molars above and below. The inferior molars in this reconstruction appear to be six crested. In the paratype grinders of the same species from Mannersdorf, Austria (Fig. 318), the inferior molars are five and a half crested.

Schlesinger, 1922, p. 7.—"Der weitaus hervorragendste Rest unter den Mastodonten der Budapester Sammlungen gehört dem in meiner Monographie [Footnote: 'G. Schlesinger:

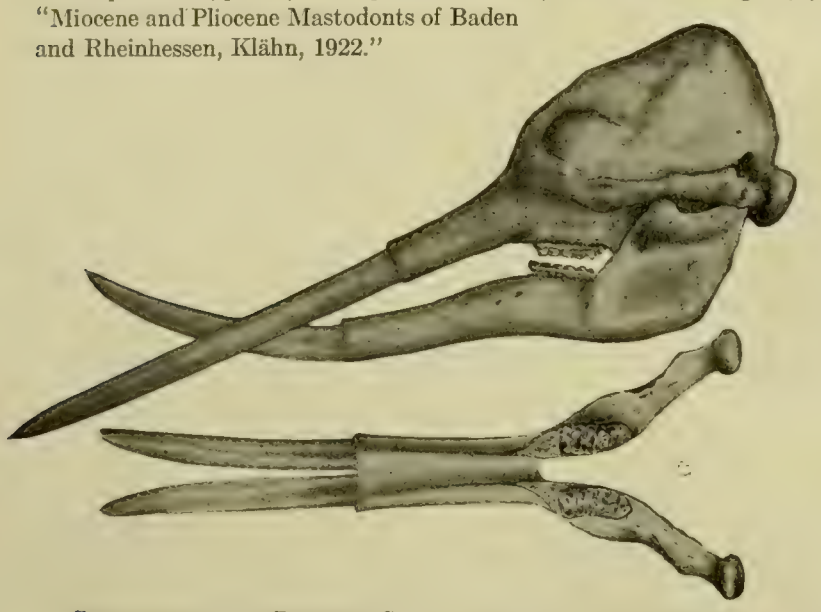
Schlesinger, 1922, pp. 154–167.—Schlesinger continues with a detailed comparison of the superior and inferior milk molars with those of '*Mastodon*' *angustidens*, '*M.*' *longirostris*, and '*M.*' *arvernensis* grinding teeth (pp. 154–162). He concludes (p. 163) that '*Mastodon*' *grandincisivus* should be reckoned with the tetralophodont '*Mastodon*' *longirostris* and '*M.*' *arvernensis*. He gives as special characters of the grinding teeth of '*M.*' *grandincisivus* the following (Schlesinger, 1922, p. 165 and p. 167): "Molaren stets von riesigen Dimensionen, Sperrhöcker auch an der posttriten Seite entfaltet, an der prätriten vorne und hinten gleichstark, Täler mässig weit *M. grandincisivus* Schles. . . . Molaren von ausserordentlichen Dimensionen, mit 5×—6 Jochen; Täler weiter als bei *M. longirostris*, Halbteile pfeilförmig gegeneinanderstrebend (insbesondere vom 3. Joch an). Sperrhöckerbildung sowohl prä- wie posttriterseits stark (namentlich an den hinteren Jochen) und kräftiger an den Rück- als Vorderseiten (entgegen *M.*

longirostris). Zement in den Taltiefen reichlich, die Joche oft zum Teil verhüllend. . . . *M. grandincisivus* Schles."

Summary of Characters of 'Mastodon' grandincisivus.—(Schlesinger, 1922, p. 259): "2. Reihe *M. angustidens* → *M. grandincisivus*: *a*) Verkürzung des Schädels, Erhöhung des Domes. *b*) Exzessives Auswachsen der Mandibelsymphyse. *c*) Schmelzbandverlust der I^2. *d*) Streckung der I^2 zur Lyraform. *e*) Exzessive Entfaltung der I_2. *f*) Reduktion der Molarenzahl. *g*) Jochvermehrung zur Tetralophodontie. *h*) Prämolarenschwund. *i*) Reduktion des Sperrhöckers an der Rückwand der hinteren Joche."

Tetralophodon gigantorostris Klähn, 1922

Klähn (1922, p. 87) described without figure a lower jaw from Bermersheim, Germany, in the Mainz Museum which he named *Mastodon gigantorostris*. A brief résumé of this species appears in Chapter VIII, p. 282, of the present Memoir, under the heading "Miocene and Pliocene Mastodonts of Baden and Rheinhessen, Klähn, 1922."



Reconstruction of Referred Skull and Jaws of Tetralophodon (Trilophodon?) grandincisivus

Fig. 320. Reconstruction of adult male *Mastodon* (*Bunolophodon*) *grandincisivus* Schlesinger. After Schlesinger, 1922, Taf. I: "Figur 1: Rekonstruktion des Schädels samt Unterkiefer von der Seite, auf Grund der Reste von Pestszentlörincz. Figur 2: Rekonstruktion des Unterkiefers von oben gesehen." It appears from this reconstruction that Schlesinger regards the geographic range of this species as extending from Maragha, Persia, on the east, to Hungary on the west.

Pathan) age, the cotypes of *T. punjabiensis* (Dhok Pathan horizon) are also of Middle Pliocene age. One may first quote Pilgrim's observation (1913, p. 293) that the affinity between *T. punjabiensis* of the Dhok Pathan and *T. longirostris* of Eppelsheim is close: . . . "the tetralophodont type seen at Pikermi in *Tetrabelodon longirostris* is also represented in the Dhok Pathan zone by a species which we may know by Lydekker's name of *T. punjabiensis*. That it had an elongated symphysis is certain, although it seems likely that only the males were provided with lower tusks. The affinity between *T. punjabiensis* and *T. longirostris* is very close."

Male Lower Tusks.—We may connect Pilgrim's observation as to the probable *absence* of lower tusks in females with that of Lydekker when he remarks on the absence of lower tusks in the Middle Pliocene *Tetralophodon* (*Lydekkeria*) *falconeri* described above.

Cotypes.—Lydekker designated his cotypes as follows (Lydekker, "Catalogue of the Fossil Mammalia in the British

Fig. 321. Referred superior and inferior grinders, M^3-M_3, of *Tetralophodon grandincisivus* (?) from Pestszentlörincz, Komitat Pest, Hungary, after Schlesinger, 1922, Taf. IV, figs. 1 and 3, one-fourth natural size. Compare figure 310, *Tetralophodon* (*Lydekkeria*) (?)*falconeri*.

This specific reference is doubtful (compare M^3, this figure, and M^3 paratype, Fig. 318). We observe fewer ridge-crests $\frac{5\,1\frac{1}{2}}{5\,1\frac{1}{2}}$, also a relatively feeble development of the double trefoils, e.g., in the tetartolophid of M_3. These molars with single trefoils appear to belong to a much more primitive stage of *Tetralophodon* than *T. grandincisivus*, namely, similar to *T.* (*Lydekkeria*) *sinensis* (Fig. 311), or *Trilophodon* sp.

Tetralophodon punjabiensis Lydekker, 1886

Figures 306, 308C, 322–325, 329, and 338

Punjab, Dhok Pathan horizon, Siwaliks, India = Middle Pliocene. Compare *Tetralophodon falconeri* above.

This Middle Pliocene stage of Dhok Pathan is similar in molar evolution to *Tetralophodon longirostris* of Eppelsheim and *T. campester* of Kansas, as confirmed by the recent discovery of the complete cranium described and figured below. Thus we may revise the original and the more recent descriptions of Lydekker and of Pilgrim.

Geologic Level.—(Hopwood, letter, 1932) The type of *Tetralophodon* (*Lydekkeria*) *falconeri* is of Middle Pliocene (Dhok

Museum," 1886, p. 60): "*Mastodon punjabiensis*, Lydekker, n. sp. The specimens [Footnote: 'All the specimens from the Punjab included under *M. perimensis* in the Cat. Siwalik Vert. Ind. Mus. Calcutta, pt. i. pp. 97–99 (1885).'] on which this species is founded were originally referred to *M. perimensis*, while one of them was subsequently classed with *M. cautleyi*."

Lectotype, Osborn, 1923: We may select as the most recognizable of these cotypes a third inferior molar of the left side, $l.M_3$, the specimen first mentioned [as an upper true molar, M^3] in Lydekker's description, namely, (*op. cit.*, p. 60): "M.2855. Cast of the third left upper true molar, in an early stage of wear. The original was obtained from the Pliocene Siwaliks of the Punjab,

and is preserved in the Indian Museum, Calcutta (No. A.46); it is figured by the present writer in the 'Palæontologia Indica,' ser. 10, vol. *i.* pl. *xlii.* (as *M. perimensis*). Its dimensions are 0,242× 0,093; it differs widely from the corresponding tooth of *M. perimensis* (No. 40679), and still more from that of *M. cautleyi* (No. M. 2705); there are five ridges and a very narrow hind talon, consisting of three large columns, which are not arranged in a transverse line. Made in the Museum, 1886." In the American Museum the cast of this cotype bears the number 14283.

Cotype Specimens.—The other specimens clearly designated by Lydekker (1886.1, p. 60) are: Brit. Mus. 3428, fragment of a left maxilla; Brit. Mus. 3427, cast of a second left lower true molar. According to Pilgrim (see Fig.413, Vol. I, and Table, Vol. II), specimens which may be referred to *T. punjabiensis* occur also in the Salt Range, Middle Siwaliks, of Middle Pliocene age.

Specific Characters (Osborn, 1923).—The measurements of M_3 (ap. 242, tr. 93, index 38) should be compared with those of the five and a half crested type of *Tetralophodon longirostris* (ap. 189, tr. 70, index 37), also with those of the Lower Pliocene species of America, *Tetralophodon campester*, in which the measurements of M_3 are: ap. 195, tr. 80, index 41. We conclude that the third lower molar of *T. punjabiensis* is relatively longer and narrower than that of *T. longirostris;* in these proportions it also exceeds in narrowness the corresponding tooth of the American tetralophodont *T. campester* (see Fig. 308 D); it agrees with *T. campester* in the presence of five and a half plus crests, although in *T. campester* there is a rudimentary sixth (½) crest in front of the protolophid; it differs from *T. campester* in the small amount of cement in the valleys.

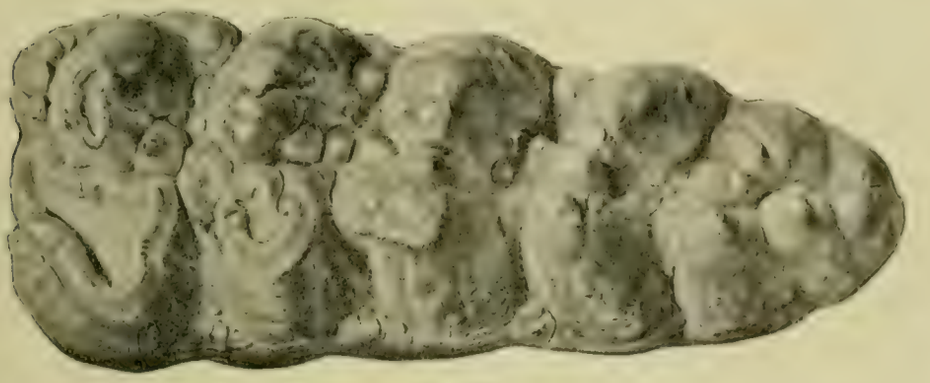


Fig. 322

Osborn's Lectotype of Tetralophodon punjabiensis

Fig. 322. One of the cotypes, l.M_3 (=lectotype) of *Mastodon punjabiensis* Lydekker, 1886, p. 60, originally figured as *Mastodon* (*Tetralophodon*) *perimensis* (Ind. Mus. A.46). After Lydekker, 1880, Pl. xlii, one-half natural size. From the Dhok Pathan, India.

Lydekker erroneously (*op. cit.*, Pl. xlii) describes this five and a half crested type as a "Third left upper true molar; from the Punjab: drawn of the natural size, and viewed from the inner side." Its long narrow proportions (as compared with M_3 in *M. longirostris*) suggest that it is a third left lower true molar. Casts: Brit. Mus. M. 2855; Amer. Mus. 14283.

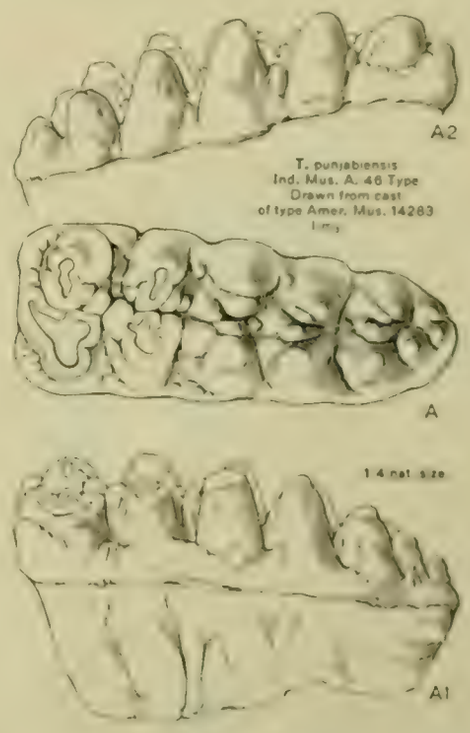


Fig. 323

Fig. 323. New figure of lectotype, l.M_3, of *Mastodon* [=*Tetralophodon*] *punjabiensis*.

A, Crown view of third left inferior molar, showing incipient double trefoils in protolophid and metalophid.

A1, External view of same molar, with five and a half plus crests.

A2, Internal view of same molar exhibiting five and a half plus crests and double trefoils in the two anterior valleys.

Specific Characters.—Lydekker (1886.1, p. 60) observes: "The cheek-teeth are narrow, and have no appreciable amount of cement, the last true molar being still more elongated than in *M. perimensis*. There is no distinctly alternate arrangement of the columns, which are very tall and of great antero-posterior thickness. . . . The species appears to be a more specialized form allied to *M. longirostris*. . . . Its dimensions are 0,242×0,093; it differs widely from the corresponding tooth of *M. perimensis* (No. 40679), and still more from that of *M. cautleyi* (No. M.2705); there are five ridges and a very narrow hind talon, consisting of three large columns, which are not arranged in a transverse line."

Unfortunately the specific characters assigned by Lydekker were given under the belief that the third molar belonged in the upper jaw. Consequently these characters should be corrected by the specific characters of Osborn, 1923, as given below.

REFERRED CRANIUM OF TETRALOPHODON PUNJABIENSIS

See Figures 306 and 324

Approximately 500 feet below the summit of the Middle Siwaliks, Middle Pliocene, discovered three miles west of Dhok Pathan on the same geologic level as the *Hipparion punjabiense* ref. quarry, also on the same level as the cranium of *Synconolophus dhokpathanensis*.

This unique cranium, with superior dentition, enables us to thoroughly establish the generic and specific characters of the Dhok Pathan stage of *Mastodon* [=*Tetralophodon*] *punjabiensis* Lyd. The measurements of M^3 are 209 mm. × 96 mm., as compared with 242 mm. × 93 mm., Lydekker's measurements of the type M_3 of *Tetralophodon punjabiensis* (Figs. 322 and 323). Especially important is the enamel band of the superior tusks which is wanting in the contemporaneous *Synconolophus dhokpathanensis*.

Approximately 500 feet below the summit of the Middle Siwaliks, Barnum Brown discovered in 1922 this superb skull of

Tetralophodon punjabiensis (Amer. Mus. 19686, Field No. 42), as well shown in five aspects in figure 324 (A, lateral, A1, palatal, A2, superior, A3, occipital, and A4, lateral view of r.M^3). This cranium is an unmistakable *Tetralophodon*, with an apparent ridge-crest formula of M 2 $\frac{4\ 1/2}{}$ M 3 $\frac{5\ 3/4}{}$, and with cement in the valleys (dotted areas in Fig. 324, A1, A4). The second superior molars are well worn, with four ridge-crests clearly indicated and a rudiment of a fifth, i.e., ⅓; on the right and left superior grinders single *internal* trefoils appear in the form of median conules, rudiments of *external* trefoils are seen on the protoloph and metaloph. The lophs are elevated or subhypsodont, as in the lectotype of *Mastodon* [= *Tetralophodon*] *punjabiensis* Lydekker (Figs. 322, 323), in which also strong *external* trefoils appear on all the ridge-crests, while *internal* trefoils are rudimentary on the protoloph and metaloph.

As characteristic of *Tetralophodon*, both superior molars (Figs. 306, 324 A1, 325) narrow posteriorly, but the third inferior molars have a higher ridge-crest formula, namely; referred M 3 $\frac{5\ 3/4}{}$, type M 3 $\frac{}{5\ 1/2+}$, i.e., rudiment of a heptalophid (see Fig. 323). A lateral enamel band appears at the tip of the left tusk (Fig. 324A). The cranium in lateral view shows a more rounded temporal region than that of *Tetralophodon grandincisivus* (Fig. 320, after Schlesinger). The contracted palate (Fig. 324 A1), with posterior nares directly opposite the pentaloph (5) of M^3, is totally different in position from the elongated palate and backwardly placed narial opening of the cranium of *Synconolophus dhokpathanensis* (Fig. 630 A1).

Osborn, 1927: Our conclusion is that *Tetralophodon punjabiensis* of the Middle Pliocene of India is in the same evolutionary stage as *T. campester* of the Lower Pliocene of Kansas but is distinguished from it by the more elongate third inferior molar teeth.

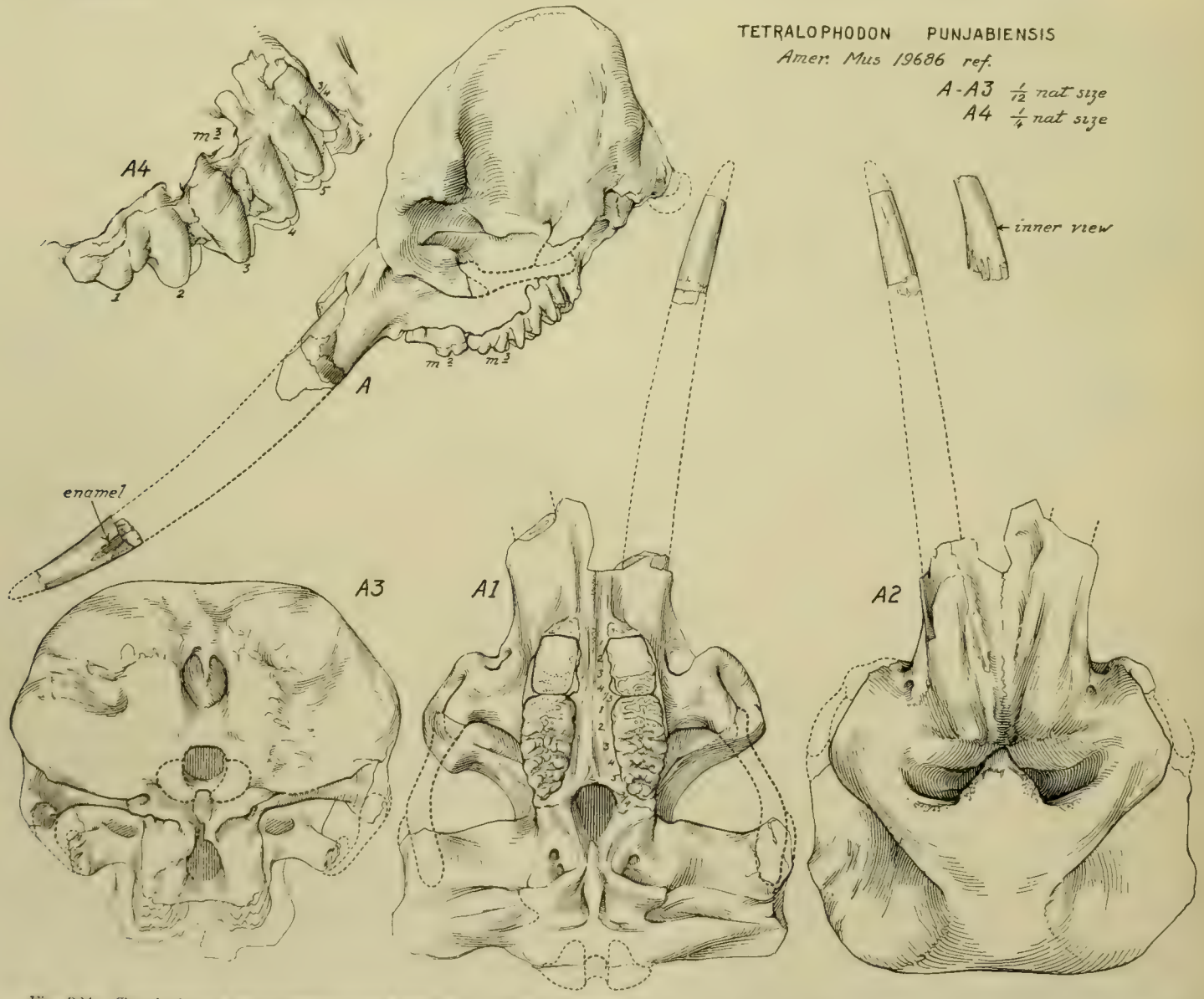


Fig. 324. *Tetralophodon punjabiensis* referred cranium (Amer. Mus. 19686), discovered by Barnum Brown three miles west of Dhok Pathan, approximately 500 feet below the summit of the Middle Siwaliks, Middle Pliocene, on the same geologic level as the *Hipparion punjabiense* ref. quarry, also on the same level as the cranium of *Synconolophus dhokpathanensis*. Compare *Tetralophodon grandincisivus* (Fig. 320).

A–A3, Four views of cranium, one-twelfth natural size. A4, Third superior molar, one-fourth natural size.

7. TETRALOPHODON FROM JAVA

Tetralophodon bumiajuensis van der Maarel, 1932

Figures 326, 327

From Bumiaju, central Java. Pliocene.

The discovery (van der Maarel, 1932) of a *Tetralophodon* in the Pliocene of Java is singularly welcome, especially in a horizon which was said to contain a primitive elephant resembling (?)*Archidiskodon planifrons* (van der Maarel, 1932, p. 3, *h*, and *i*, also Pl. xv, figs. 5, 6, and Pl. xvii, figs. 1, 2); the l.M_3 resembles *Palæoloxodon* rather than *Archidiskodon*. In its dental evolution (Fig. 326) and in the size and indices of the molars *Tetralophodon bumiajuensis* resembles the type of *Tetralophodon longirostris* (ap. 189 mm., tr. 70 mm., I. 37), rather than the lectotype of *T. punjabiensis* (ap. 242 mm., tr. 93 mm., I. 38—see Fig. 322); it is relatively brachyodont.

Tetralophodon bumiajuensis van der Maarel, 1932. "Contribution to the Knowledge of the Fossil Mammalian Fauna of Java," pp. 2, 3, 108–121. Type.—Fragmentary right mandibular ramus with M_3 *in situ* (Pl. viii, fig. 2, Pl. ix, fig. 3, and text figs. 17, 18), from Bumiaju, Excavation 8; fragmentary upper jaw with injured left and right M^3 *in situ* (Pl. ix, figs. 1, 2, and text fig. 19), from Bumiaju, Excavation 1–4 at Kali Glagah; also fragment of cranium with left and right M^3 *in situ* (Pl. viii, fig. 1, Pl. x, figs. 2, 3, and text figs. 20, 21) with detached upper incisive tusk probably belonging to the same individual (Pl. x, fig. 1) from Bumiaju, Excavation 1–4 at Kali Glagah. All specimens, including limb bones and pelvis, now in the collections of the Geological Survey at Bandung, Java. Cast of type r.M_3 (Amer. Mus. 26976). Horizon and Locality.—From Bumiaju, central Java. Pliocene.

Upper Pliocene Age.—Van der Maarel states on page 197 (*op. cit.*, 1932) that "The Bumiaju fauna does not contain recent forms; the Trinil fauna does. . . . In the Bumiaju beds a very primitive species of *Elephas* (*A. planifrons*) has been found; in the Trinil beds it is absent." (P. 198) "The Bumiaju specimens are always well fossilized; in the Trinil specimens the state of fossilization is in some cases far less progressed. . . . The Bumiaju beds are considerably more folded than in the Trinil beds."

(P. 199) "Summary. 1. The Bumiaju fauna is older than the Trinil fauna. 2. The Trinil fauna is certainly of pleistocene age more particularly either Lower or Middle Pleistocene, but not Upper Pleistocene. 3. Accordingly the Bumiaju fauna is of upper pliocene or lower pleistocene age."

Specific Characters.—(Cf. van der Maarel, *op. cit.*, pp. 108–121) *Tetralophodon bumiajuensis* is founded on a male cranium, jaw, and tusks. Third right inferior molar, r.M_3, with prominent ectotrefoils, no entotrefoils, five transverse ridge-crests, a fore-and-aft talon, three anterior ridge-crests of approximately equal width; length 180 mm., breadth 70e mm., index 39e, pentalophid bearing four conelets, hexalophid low, rudimentary, consisting of three conelets. Fractured palatal cranium (Pl. viii, fig. 1), with right and left third superior molars; upcurved incisive tusks; l.M^3 much worn, with 5¼ ridge-crests, length 170 mm., crown narrowing posteriorly, pentaloph small and narrow, hexaloph with two cones. Inferior incisors absent.

Osborn, 1932: As shown in the comparative table of measurements and indices of the present Memoir (p. 351), the grinding teeth measurements are inferior in size to those of *Tetralophodon punjabiensis* of India, approaching more nearly those of the *T. longirostris* of Germany. The third lower molar of *T. bumiajuensis* bears 5½ ridge-crests; it is in about the same stage of loph and conelet evolution as the l.M_3 of the Lower Pliocene *T. punjabiensis* of India (see Fig. 308C). It is more progressive than the r.M_3 in *T. longirostris* (see Fig. 308A).

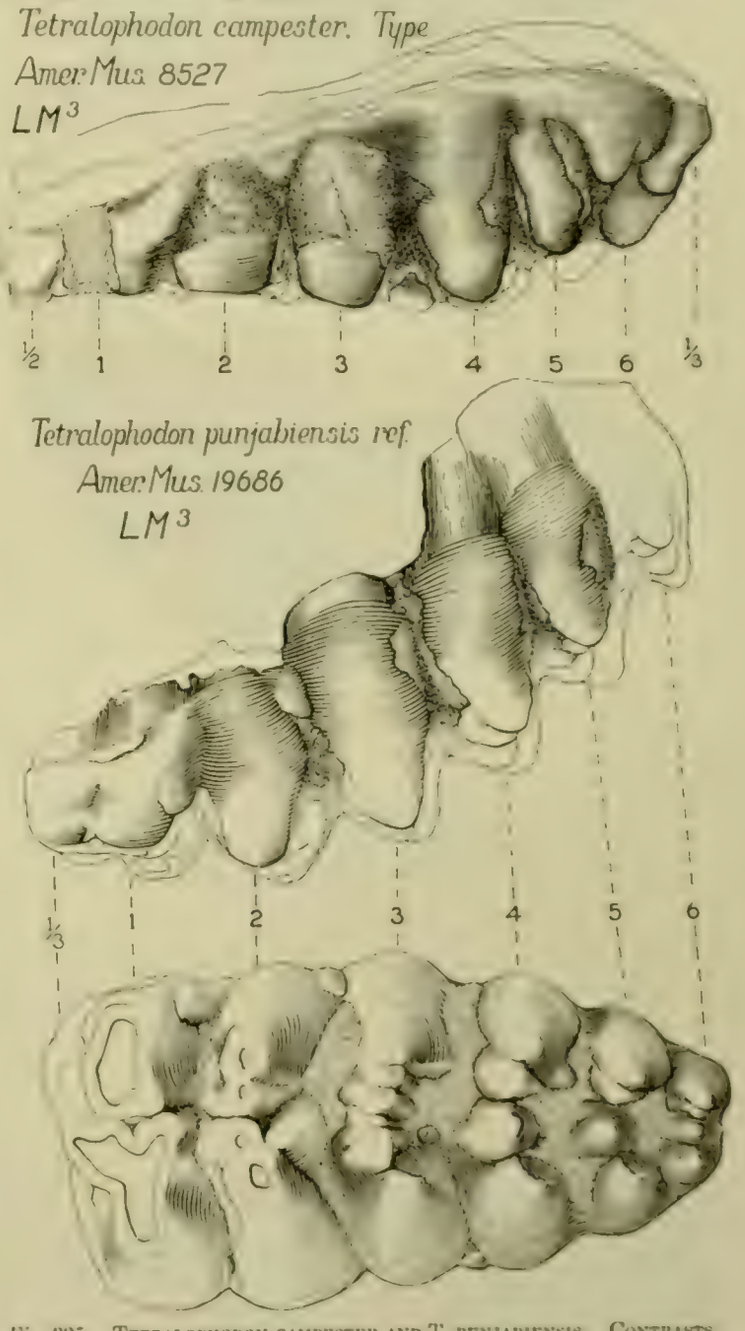
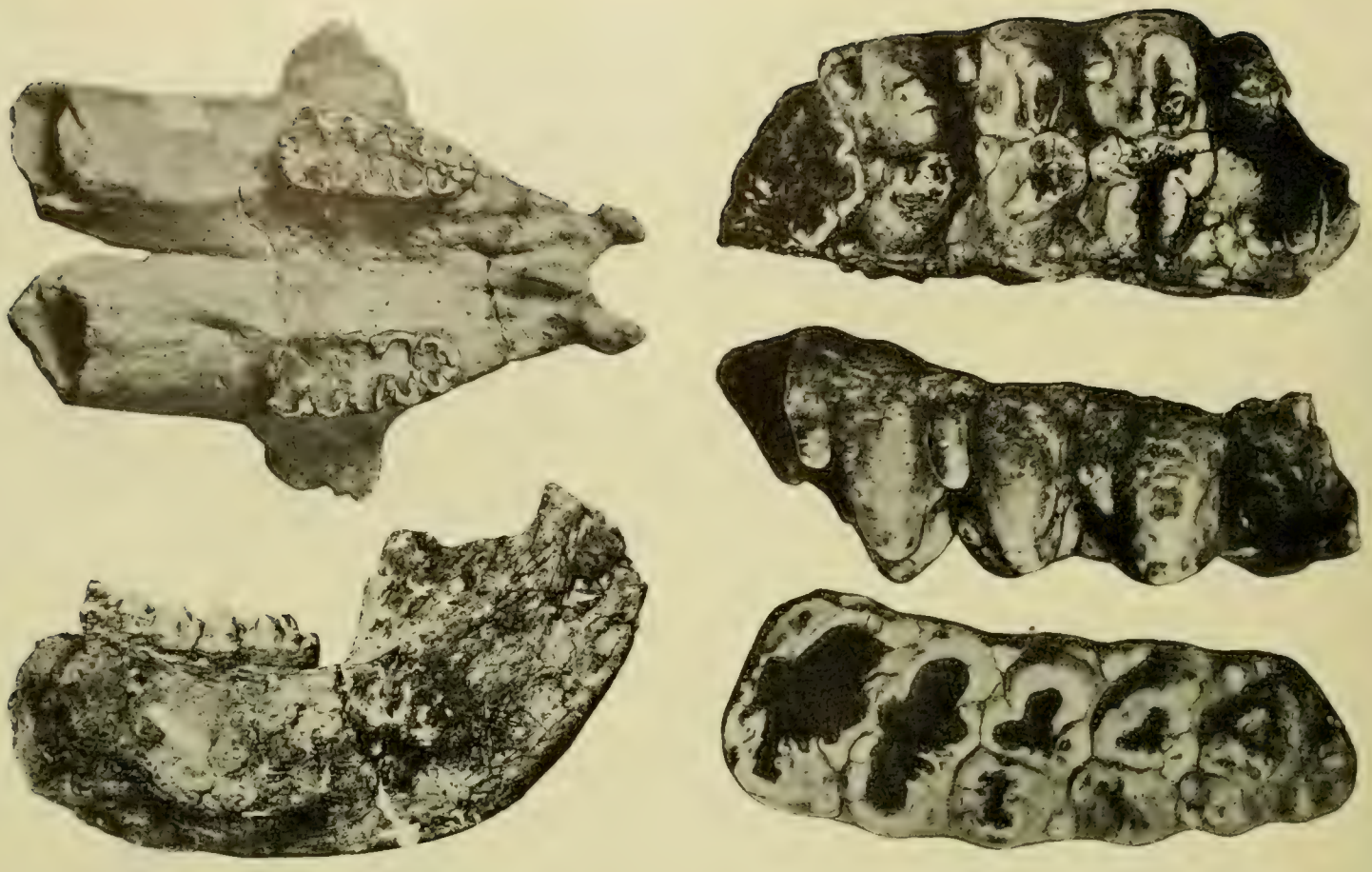


Fig. 325. Tetralophodon campester and T. punjabiensis. Contrasts and Resemblances. Compare Figures 308, 329

About one-half natural size

Tetralophodon campester (Amer. Mus. Cope Coll. 8527) is slightly more hypsodont than *T. punjabiensis* (Amer. Mus. 19686); both grinders are 5½–6 ridge-crested or hexalophoid, the *T. campester* type showing the rudiment of a heptaloph (⅓). In *T. campester* (Fig. 331 A1) prominent ecto- and entotrefoils appear on both the proto- and metalophs.

Tetralophodon punjabiensis: The transverse crests represent a type more *zygodont* than *T. campester*, in the *absence* of entotrefoils excepting on M^1, M^2; moreover the triangular form of l.M^3 and the three anterior crests, proto-, meta-, and tritolophs, suggest a resemblance to *Stegolophodon cautleyi* (cf. Pl. iv H) rather than to *T. campester*.



TYPE OF TETRALOPHODON BUMIAJUENSIS VAN DER MAAREL, 1932

Fig. 326. Type cranium, jaw, and five to six ridge-crested grinders of *Tetralophodon bumiajuensis* van der Maarel, 1932, Pl. VIII, figs. 1, 2, and Pl. IX, figs. 1, 2, 3.

(Upper left) Palate preserving M^3 with $5\frac{1}{3}$ ridge-crests. About one-fifth natural size.

(Lower left) Mandible preserving M_3 with 5+ ridge-crests. About one-fifth natural size.

(Upper right) Fragment of right third superior molar, with double trefoils on proto- and metalophs. One-half natural size.

(Middle right) Lateral view of same showing rather blunted trito-, tetarto-, and pentalophs. One-half natural size.

(Lower right) Type right third inferior molar (cast Amer. Mus. 26976) showing ectotrefoils on proto- to tetartolophids. One-half natural size.

These grinders are more progressive than those of *Tetralophodon punjabiensis* in the presence of ecto- and entotrefoils. In the height of the three to four anterior ridge-crests, they are in a stage similar to that of *T. longirostris* of Eppelsheim.

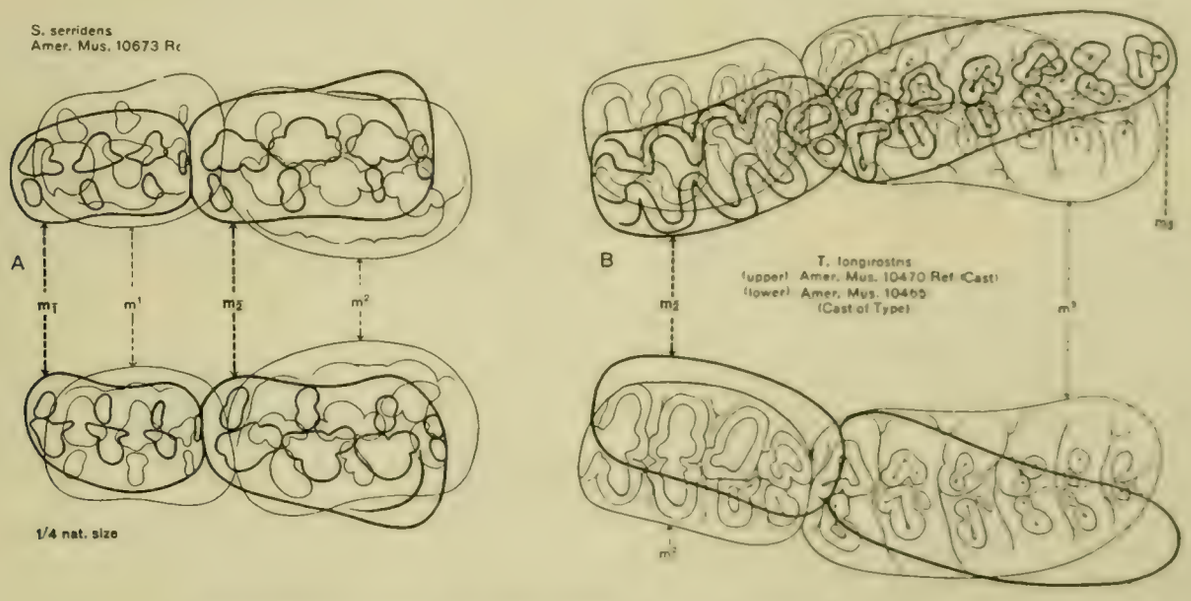
Fig. 327. Central Java including the type horizon of *Tetralophodon bumiajuensis* (16) and the Plio-Pleistocene fossil localities of Java.

NOTE (1934): The Kendeng horizon along the Solo River contains the classic *Pithecanthropus erectus* Dubois associated with two species of proboscideans, *Stegodon airâwana* and *Palæoloxodon hysudrindicus* of Middle Pleistocene age. The Bumiaju horizon, yielding *Tetralophodon bumiajuensis*, appears to be of Middle to Upper Pliocene age (cf. complete map of Java in Vol. II, Chap. XVI).

8. AMERICAN SPECIES OF TETRALOPHODON, OF LOWER TO MIDDLE PLIOCENE AGE, NAMELY, T. CAMPESTER AND T. ELEGANS

First we may point out (Fig. 329) that the grinders of *Tetralophodon* become more hypsodont and complicated than those of *Trilophodon* (Chap. VIII) or of *Serridentinus* (Fig. 328A).

Trilophodon has fewer and simpler crests; *Tetralophodon* has more numerous and more complex crests; the diagram (Fig. 328B) enables us to understand that the mechanical relations of the upper and lower teeth are profoundly different in the two phyla: *Trilophodon* maintains more of the chopping motion characteristic of the primitive Bunomastodontidæ; *Tetralophodon* gradually acquires a grinding motion, hypsodonty, cement, double trefoils, and a sublabyrinthine condition of the enamel which reminds us of that in the Humboldtinæ. The grinding teeth in the brevirostral *Stegomastodon*, however, are readily distinguished, first, because they possess



SERRIDENTINUS (LEFT) AND TETRALOPHODON (RIGHT) GRINDING TOOTH OPPOSITION

Fig. 328. Reciprocal mechanical form of upper and lower grinding teeth. Upper molars (light lines), lower molars (heavy lines). After casts of type and referred molars of (A) *Serridentinus* and (B) *Tetralophodon*. One-fourth natural size.

A, *Serridentinus serridens* ref. (Amer. Mus. 10673), *single* trefoils on *outer* side of lower molars (heavy), on *inner* side of upper molars (light). Both M^2 and M_2 trilophodont.

B, *Tetralophodon longirostris* Kaup, casts of type and referred molars.

quadruple trefoils in place of the *double* trefoils of *Tetralophodon*, second, because the internal and external cones are alternate not opposite, and, third, because the known *Stegomastodon* molars are much less hypsodont and cemented than those of *T.* (*Morrillia*) *barbouri*.

The reciprocal mechanical relations of the upper and lower grinding teeth of *Serridentinus* and *Tetralophodon* are also clearly illustrated in the diagram (Fig. 328). The *upper* (light lines) and *lower* (heavy lines) grinders are superposed on each other exactly as they mechanically reciprocate in the grinding motion of the jaws. The principle of *mechanical reversal* in form is maintained throughout, as will be seen by closely comparing part for part. The upper teeth are broader and shorter in proportion; the lower teeth are longer and narrower in proportion. The upper and lower trefoils face each other.

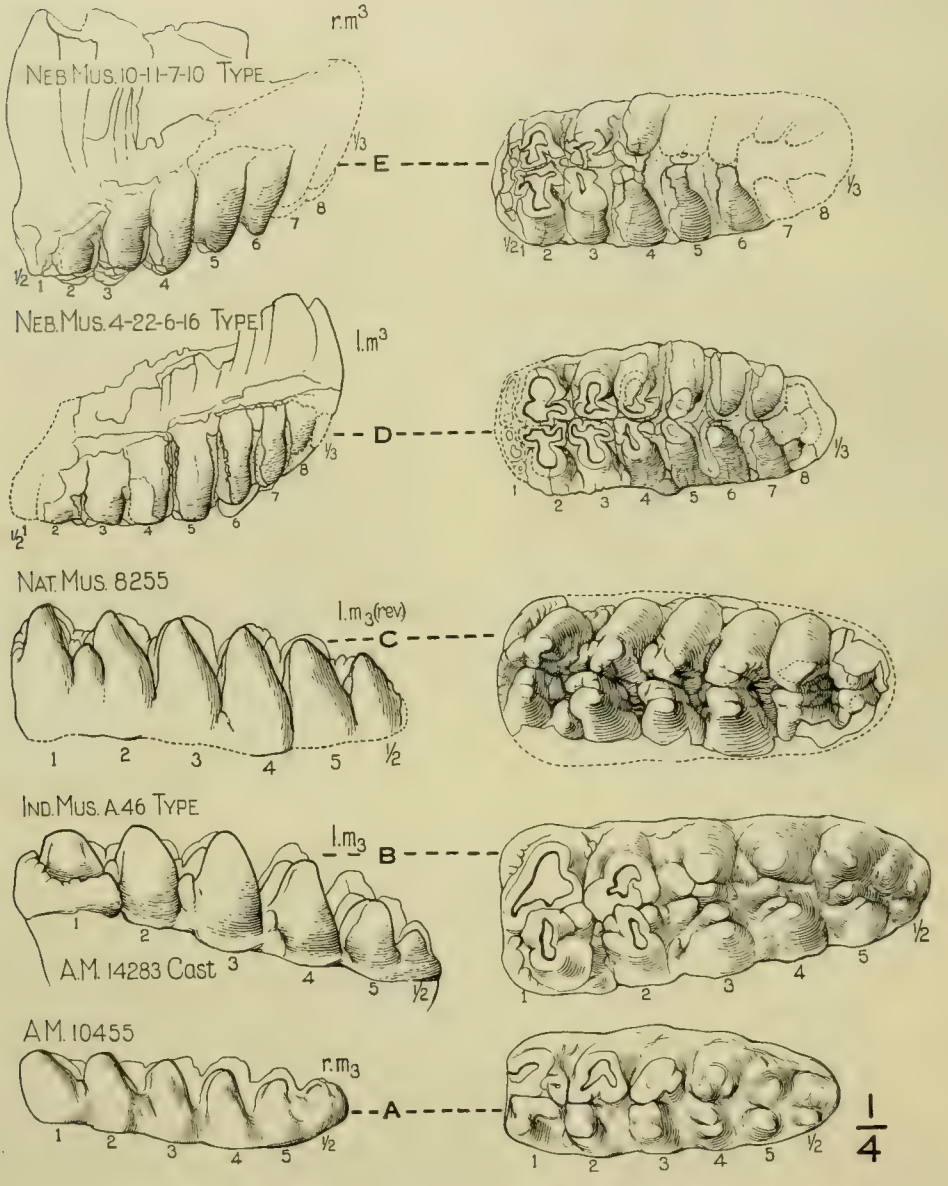


Fig. 329. Extreme Pliocene Evolution of Tetralophodon Molars (cf. Fig. 308)
All figures one-fourth natural size

From the 5½ ridge-crested *Tetralophodon longirostris* (A) of the Lower Pliocene of Eppelsheim, there is a marked ascent into the somewhat elevated molar crown of *T. punjabiensis* (B) of the Middle Pliocene of India, into the still more hypsodont *T. elegans* (C) of the Middle to Upper Pliocene of Kansas, and finally into the extremely hypsodont 8⅓ ridge-crested *T. (Morrillia) barbouri* (D, E) of the Middle Pleistocene of Nebraska. This progressive hypsodonty and addition of ridge-crests is in marked contrast to the relatively stationary condition of the third molars of *Trilophodon*.

E, *Tetralophodon precampester* type = *T. (M.) barbouri* ref. Neb. Mus. Middle Pleistocene of Nebraska.

D, *Tetralophodon (Morrillia) barbouri* type. Neb. Mus. Middle Pleistocene of Nebraska.

C, *Tetralophodon elegans* type. Nat. Mus. Middle to Upper Pliocene of Kansas.

B, *Tetralophodon punjabiensis* type. Ind. Mus. Middle Pliocene of India.

A, *Tetralophodon longirostris* type. Darmstadt Mus. Lower Pliocene of Eppelsheim. The catalogue number should read: A. M. 10465 (cast).

Phylum *Trilophodon* in America

Milk premolars and 'intermediate molars' trilophodont.

Third inferior molars originally four and a half crested, progressively five and a half crested.

Central conules between ridge-crests relatively constant.

Not, so far as we know, encased with cement.

Persistently brachyodont; summits of crests separate.

Single trefoils on one side of the upper and lower crowns; rudiments of double trefoils only in final stages.

Lower incisive tusks very prominent, typically prod-like, secondarily absent.

See also characters of the *Trilophodon* phylum enumerated above in preceding sections of this chapter, and in Chapter VIII.

Phylum *Tetralophodon* in America

Milk premolars and 'intermediate molars' tetralophodont.

Third inferior molars progressively five and a half crested to eight and a third crested; cement early appearing in the valleys and rising to the summits of the crowns; progressive hypsodonty very marked, crests elongated vertically becoming closely compressed at the summits and finally attaining a parallel columnar form in *T.* (*Morrillia*) *barbouri;* double trefoils becoming more and more distinctly marked until they are equal on the inner and outer sides in *T.* (*M.*) *barbouri;* apparently a supplementary anterior crest (ant.) arising in *T.* (*M.*) *barbouri* ref. in front of the protoloph; supplementary posterior crests arising behind the pentaloph, namely, hexaloph and heptaloph. *Central conules* variable.

Lower incisive tusks variable, or absent(?) in females (*T. campester*).

The above diagrams (Figs. 282, 308, 329) illustrate clearly the contrasts of *Trilophodon* with the ascending mutations in the American species referred to *Serridentinus* and *Tetralophodon*. The phyletic relations of *Tetralophodon* are positively established by the single fully known stage of *Tetralophodon campester*. The four species in America which at present we are inclined to refer to the *Tetralophodon* phylum are the following in ascending order:

Tetralophodon (*Morrillia*) *barbouri*, by far the most progressive, eight ridge-crests.
Tetralophodon elegans, intermediate.
Tetralophodon campester, slightly less progressive than *T. elegans*.
Tetralophodon fricki, the least progressive, five ridge-crests.

Generic Distinctions.—We observe that the ascending series of species of *Tetralophodon* (Fig. 308), namely, *T. fricki* (B), *T. campester* (D), and *T.* (*Morrillia*) *barbouri* (F, E), may be clearly distinguished from the ascending series of species of *Serridentinus* and of *Trilophodon* (Fig. 282), namely, *Serridentinus productus* (A), *S. progressus* (B), and *Trilophodon giganteus* (C). The differences correspond with those between the phylum *Tetralophodon* and the phylum *Trilophodon* already pointed out in the above summary.

Tetralophodon campester Cope, 1878

Figures 308D, 325, 330, 331, 336, and 349

Republican River horizon, Sappa Creek, Rawlins County, Kansas, Lower Pliocene, probably of somewhat more recent geologic age than Pikermi, Eppelsheim, and Maragha.

Compare *Gomphotherium* [=*Tetralophodon*] *elegans* Hay, 1917

At present this is the best known species of *Tetralophodon* in America; Cope named it in 1878, and published his type figure of the skull and jaws in 1889; the skull and jaws are fully illustrated by Cope and Matthew (1915, Pls. cxx–cxxiii). It occurs in a late stage of Lower Pliocene time, namely, the *Pliauchenia-Peraceras* zone of Osborn which contains *Pliohippus nobilis*, *Protohippus*, the rhinoceros *Peraceras*, and the serridentine mastodont known as *Ocalientinus republicanus*. As shown in the accompanying figure 331, it is decidedly superior in size to Kaup's type of *Tetralophodon longirostris*, the drawing of which is reversed to bring these two specimens close together for comparison. It is also, as pointed out by Cope in his type description, closely related to, but more progressive than Kaup's type of *T. longirostris*. The relative measurements and indices of these two *classic* species are as follows:

			ap.	tr.	I.		ap.	tr.	I.
T. longirostris ref. (cast, Amer. Mus. Warren Coll. 10470)	M^{2-3}	=317	M^2	123	81	66	M^3	196	89	45
T. campester type (Amer. Mus. Cope Coll. 8527)	M^{2-3}	=312	M^2	118	75	64	M^3	195	80	41

The inferior molars cannot be directly compared because they are not preserved in Cope's type specimen.

Cope's original description in 1878 of this important species is as follows:

Tetralophodon campester Cope. "Descriptions of New Vertebrata from the Upper Tertiary Formations of the West." Proc. Amer. Phil. Soc., Phila., Vol. XVII, 1878, p. 225 (Read December 21, 1877); *Pal. Bull.* No. 28, p. 225 (Pub. Jan. 12, 1878). Type.—(*Op. cit.*, p. 225: "The cranium and under jaw, with nearly complete dentition, including tusks, of this species, were obtained by my assistant, Russell S. Hill. The animal is mature but not old, as the second true (third intermediate) molar is present and much worn, and the last molar is worn on its anterior three-fifths." Amer. Mus. Cope Coll. 8527. Horizon and Locality.—(Cope, 1878, p. 227): "From the Upper Miocene and Loup Fork horizon of Kansas." Republican River beds, Sappa Creek, Rawlins Co., Kansas. Lower Pliocene. Type Figure.—Cope, Amer. Nat., 1889, Vol. XXIII, p. 204, Pls. ix, x; Cope and Matthew, U. S. Geol. Surv. Monograph Series No. 2, 1915, Pls. cxx, cxxi, cxxii, cxxiii.

Type Description (cf. Cope, 1878.1, p. 226).—1. Third molar

[superior] with six transverse crests, and so large a heel that it might be described as seven crested. 2. Each crest subtransverse, composed of principal outer and smaller intermediate cones in close contact. 3. Section by wearing of third and second crests is that of two trefoils placed base to base, completely closing the valleys. 4. Valleys of other crests closed by one or two median tubercles, less distinctly trifoliate in section. 5. Symphysis produced without abrupt contraction, channeled above by a narrow and deep groove. 6. [?] Supports no tusks, beak slightly decurved. 7. Superior incisor with broad band of enamel which covers nearly one-third the diameter. 8. It is with the *T. longirostris*, of Eppelsheim and the valley of the Danube, that the closest affinity exists.

Osborn, 1923: Of the ten characters assigned above by Cope to *T. campester*, Nos. 5 and 6 are somewhat doubtful because of the fractured condition of the anterior part of the type jaw in which Cope believed there were no tusks. Inasmuch as the *absence* of lower tusks has been noticed also in *T. falconeri* and *T. punjabiensis*, it is possible that the mandible of *T. campester* was also tuskless; Cope himself so represented it again in his second figure of the type which is here reproduced in facsimile (Fig. 330).

The true characters of this animal are more accurately displayed in comparison with *T. longirostris* (Fig. 331) in which the corresponding parts are placed side by side and drawn to the same scale. As restored by Osborn and mounted in the American Mu-

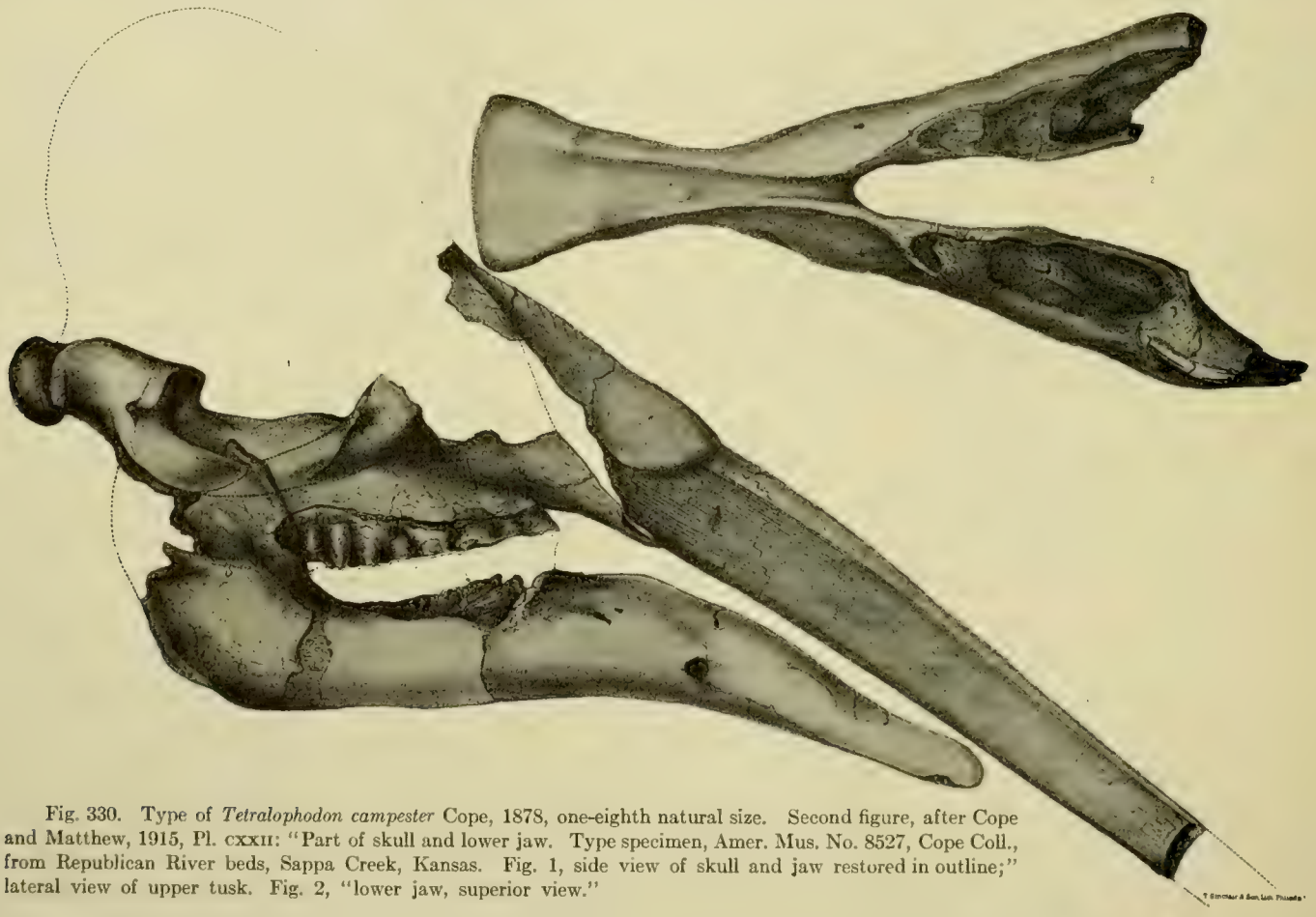


Fig. 330. Type of *Tetralophodon campester* Cope, 1878, one-eighth natural size. Second figure, after Cope and Matthew, 1915, Pl. CXXII: "Part of skull and lower jaw. Type specimen, Amer. Mus. No. 8527, Cope Coll., from Republican River beds, Sappa Creek, Kansas. Fig. 1, side view of skull and jaw restored in outline;" lateral view of upper tusk. Fig. 2, "lower jaw, superior view."

In *T. campester* the symphysis is much more robust, not being separated from the rami by any constriction, as in *T. longirostris*. 9. It is, moreover, [?] without [lower] incisive tusks, but this character may turn out to be individual or sexual. 10. In molar structure there is considerable resemblance to *T. longirostris*, but the latter possesses but five crests and a heel on the last molar [Falconer, 1857, p. 330].

Measurements

	M.
Length of crown of second true molar	.118
Width of crown of second true molar	.075
Length of crown of third true molar	.195
Width of crown of third true molar	.080

seum, the lower jaw of *T. campester* does not contract, as represented by Cope in his second type figure, but indicates the presence of an inferior incisor tusk. The enamel constitutes a band on the lower external aspect of the superior tusk, surrounding about one-third of the outer diameter; it is thus more apparent on the inferior surface (Fig. 331 A1) and hardly appears at all in the superior aspect of the skull. The superior grinding teeth in *T. campester* (A1) occupy a similar area to the grinders in *T. longirostris* (B); it will be observed that the tetartoloph of M^2 is slightly broader than that in the Eppelsheim type; the double superior trefoils are more distinctly marked in the protoloph and metaloph of M^3, but this may be due partly to the fact that they are more worn. We observe that the ridge formula, M $2\frac{4}{4}$ M $3\frac{1/2\text{-}5\text{-}1/2}{1/2\text{-}5\text{-}1/2}$, is not quite

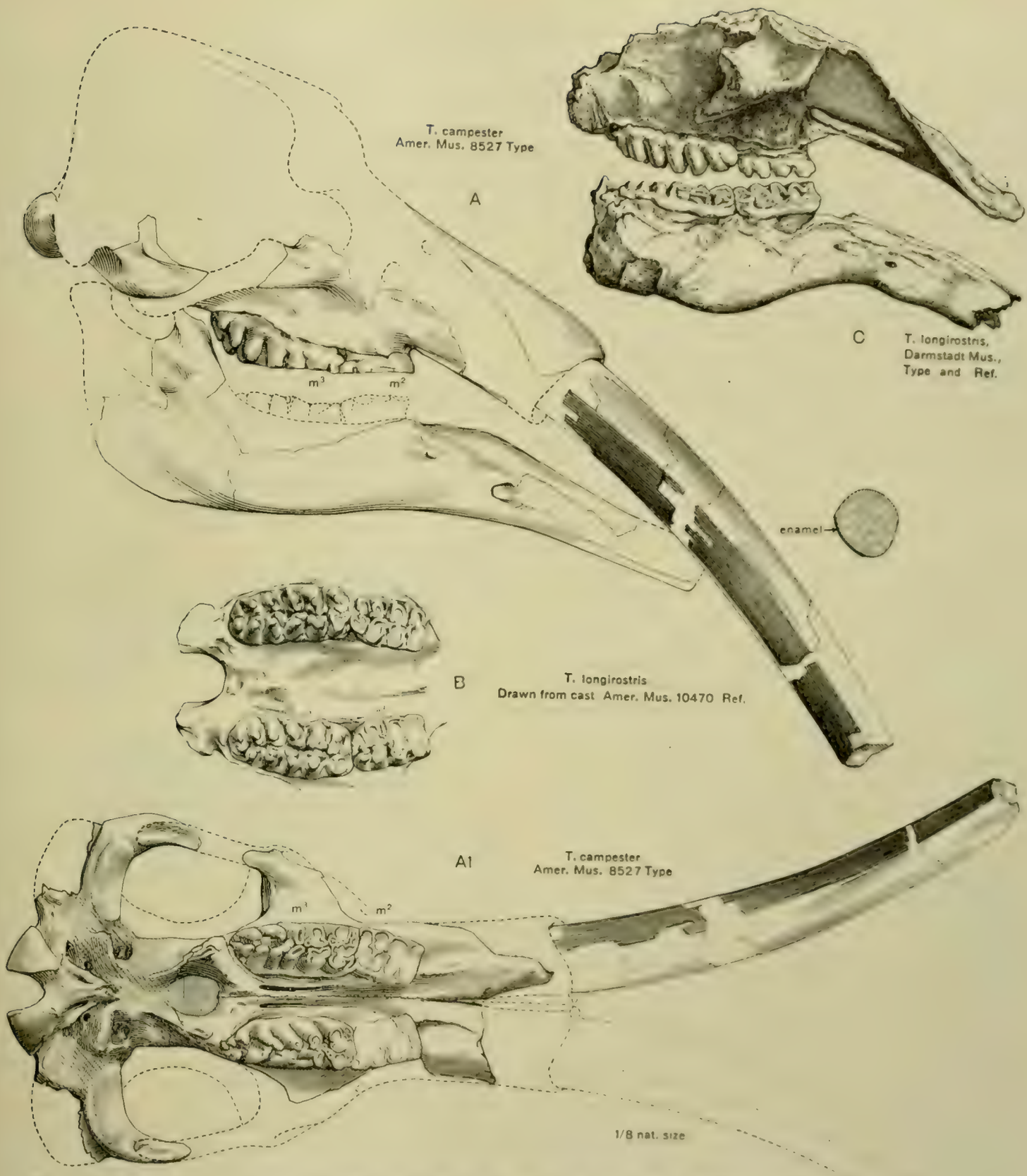


Fig. 331. Comparison of *Tetralophodon campester* type (Amer. Mus. Cope Coll. 8527), Lower Pliocene of Kansas, and *Tetralophodon longirostris* type and referred, Lower Pliocene of Eppelsheim, Germany. All one-eighth natural size.

A, Restored skull and jaws of Cope's type of *T. campester*, middle-aged individual (Amer. Mus. Cope Coll. 8527), with M^2 and M^3 *in situ*.

A1, Palatal view of same.

C, Restored skull and type jaws of *T. longirostris* Kaup, reproduced from Owen's wood engraving of Kaup's reconstruction.

B, Palatal view of *T. longirostris*, drawn from cast (Amer. Mus. Warren Coll. 10470) of Kaup's referred palate

the same in the two species; the ridge formula of M_3 in a referred specimen of *T. campester* (Neb. Mus. 22–10–8–14) has five complete crests and two half crests, the detailed structure of which is clearly shown in figure 308D of this Memoir.

Referred Tetralophodon campester Lower Molar.—A third lower molar, l.M_3 (Neb. Mus. 13–12–15), length 205 mm., breadth 84 mm., index 41; external trefoils all well developed, rudiments of internal trefoils on proto-, meta-, and tritolophids; very rudimentary pentalophid; cement in valleys. This tooth is interesting because the inferior molars are wanting in the type of *Tetralophodon campester*.

(Barbour, letter, February 8, 1927): "No. 13-12-15, about which you inquire, was found in the valley of the Republican River, Red Willow County, Nebraska, by Mr. A. Canfield of Tecumseh, Nebraska. It comes to us through his son W. W. Canfield, University of Nebraska, 1919. . . . I infer that it is Pliocene or very early Pliocene."

RIDGE FORMULA OF TETRALOPHODON CAMPESTER

Type Ridge Formula.—It is very desirable to secure an unworn M_3 of *Tetralophodon campester* from the type locality. The detailed crest structure of the type superior molars is beautifully shown in figure 336 of this Memoir. It is important to note that in his enumeration of the six and a half crests in the *superior* molars, Cope includes the half crest in front of the protoloph. It would therefore be more accurate to describe *T. campester* as possessing five complete crests and two half crests, an anterior and a posterior: M 3 $^{1/2\text{-}5\text{-}1/2}$. *T. campester* is more progressive than *T. longirostris* in the stronger development of the anterior half crest.

Ridge formula of *T. campester*: M 1 $\frac{4}{4}$ M 2 $\frac{4}{4}$ M 3 $\frac{1/2\text{-}5\text{-}1/2}{1/2\text{-}5\text{-}1/2}$.

TETRALOPHODON PRECAMPESTER[1] OSBORN, 1923

Figures 308E, 329E, and 339

Middle Pleistocene, Harlan County, Nebraska.
Synonym of *Tetralophodon* (*Morrillia*) *barbouri* Osborn, 1921.
Compare *Gomphotherium* [= *Tetralophodon*] *elegans* Hay, 1917.

Osborn, 1935: This *type* (Figs. 308E and 329E), originally described and figured on an imperfect reconstruction, now proves to be identical with the type of *Tetralophodon* (*Morrillia*) *barbouri* (see Fig. 339, p. 378 below). It was originally described by Osborn as a third inferior molar but proves rather to be a third superior molar, M^3, because of its abbreviated proportions.

Osborn's original description of this species is as follows:

Tetralophodon precampester Osborn, 1923. "New Subfamily, Generic, and Specific Stages in the Evolution of the Proboscidea." Amer. Mus. Novitates, No. 99, December 27, p. 3 (Osborn, 1923.601). Type.—A third superior molar of the right side, r.M^3 (Neb. Mus. 10–11–7–10). Horizon and Locality.—Harlan County, Nebraska. Middle Pleistocene. Type Figure.—Figures 308E, 329E, and 339 of the present Memoir.

Original Description.—(Osborn, 1923.601, p. 3); "Type, a third inferior [superior] molar of the right side from Harlan County, Nebraska, in the Nebraska Museum (Neb. Mus. 10–11–7–10). This type exhibits five complete crests, a protoloph, metaloph, tetraloph, and pentaloph, also a narrow anterior half crest, as compared with the broad anterior half crest in *T. campester;* the crown is relatively shorter and broader than that of the *T. campester* Cope type; cement fills the valleys and rises at the sides of the crowns in the tritoloph and tetraloph."

"This species is published by the kind permission of Professor Erwin H. Barbour."

Tetralophodon elegans Hay, 1917

Figures 329C, 332

Described as *Gomphotherium elegans*, from McPherson, Kansas, "Equus beds of the Pleistocene," Hay, 1917. Middle(?) Pliocene (Osborn, 1933).

Compare *Tetralophodon campester* Cope, 1878, and *T. precampester* Osborn, 1923 [=synonym of *T.* (*Morrillia*) *barbouri*]. Transferred by Hay (1923, p. 113) to *Anancus elegans*.

This species undoubtedly belongs to the phylum *Tetralophodon* in the possession (1) of double trefoils in the type molar M_3, (2) of a long narrow crown, 217 mm. by 85 mm. at fourth ridge, index 39, (3) of five complete ridges and one prominent half-ridge, a total of six which removes it from *Trilophodon;* each transverse ridge is surmounted by four conelets. In this species the ridge formula is practically the same as that in *Tetralophodon campester;* it seems to be in a slightly more progressive stage of evolution but may come within the range of *T. campester;* the specific name *Tetralophodon elegans* rests upon a six-crested type molar much less progressive than the Pleistocene species of *Morrillia*.

Characters.—In the ridge-crests the type tooth, l.M_3, is in a somewhat more progressive stage of evolution than the types of either *T. campester* or *T. precampester* inasmuch as the type third lower molar (Fig. 332) possesses five well separated crests and a half crest or talon which Hay describes as so large that it may be considered as a sixth crest. It is distinguished from *T.* (*M.*) *barbouri* by less progressive development of the anterior half crest, by the more separate condition of the five main lophs, and by the less prominent development of the double trefoils. Judging from Hay's description and type figures (Fig. 332), the trefoils are more prominently developed on the outer cones than on the inner; whereas in *T. campester* the trefoils are developed with equal prominence on both the outer and inner cones.

Hay's type description is as follows:

Gomphotherium elegans Hay. "Descriptions of Some Fossil Vertebrates Found in Texas." Bull. Univ. of Texas, No. 71, December 20, 1916 (not actually published until 1917=1917.1), pp. 21, 22. Type.—"A lower left third molar." Nat. Mus. 8255; cast Amer. Mus. 2100. Type Locality.—McPherson, Kansas. "Equus beds of the Pleistocene." Middle(?) Pliocene (Osborn). Type Figure.—Hay, Proc. U. S. Nat. Mus., 1917, LIII, Pl. xxvi, figs. 1, 2 (1917.3). Type Description.—(Hay, *op. cit.*, 1916 [1917.1], pp. 21 and 22): "Lower last molar

[1]The specific term *precampester* is a *nomen nudum*, since the type of *Tetralophodon precampester* proves to be identical with the type of the previously described *Tetralophodon* (*Morrillia*) *barbouri*, as clearly shown in Figs. 338 and 339, p. 378 below.

long and narrow; with five crests and a talon. Besides the buttresses on the outer halves of the crests, there are buttresses on the inner halves of the three anterior crests. The buttresses are composed each of one or more conules. The length of the type molar is 217 mm.; the width at the first [fourth] cross-crest, 85 mm. The talon is so large that it may be regarded as a sixth crest, but in other specimens it may be less strongly developed. The two principal cones composing each crest seem to be made up each of two subordinate cones closely pressed together. A deep narrow cleft runs the length of the tooth between the right and left halves of the crests. There is a strong tendency to the formation of conules in the valleys between the crests."

TYPE (TWO LOWER FIGURES) OF TETRALOPHODON ELEGANS

Fig. 332. Type (lower figures) of *Gomphotherium elegans* Hay, 1917.3, Pl. XXVI, figs. 1 and 2, one-third natural size. Five and a half to six crested lower left third molar, from McPherson, Kansas. Nat. Mus. 8255; cast Amer. Mus. 2100.

Referred (?) three crested tooth (upper figure) resembling *Trilophodon*, from near Waco, Texas, after Hay, 1917.3, Pl. XXVI, fig. 3; also figured in Hay, 1917.1, Pl. III, fig. 2.

"An upper right second molar which is referred to this species belongs to the collection of Baylor University. This was found in Pleistocene deposits on Hog Creek, McLennan county, Texas, not far from Speegleville, a town about eight miles west of Waco. A view of the grinding surface is here presented (pl. III, fig. 2). The crown is complete, but the roots are broken off. It appears that the inner anterior root did not extend so far under the second crest as in *Mammut americanum*. The tooth is unusually large, being 145 mm. long and 90 mm. wide. There are three crests and a large talon. The wear of the two anterior crests has produced on the inner half of each of these a large trefoil. The enamel of that part of these which joins the outer cone is considerably folded. The valleys between the crests are closed by the buttresses whose wear produces the front and rear elements of the trefoils. There are very distinct buttresses connected with the outer half of each of the crests. Here and there are accessory conules, especially at the ends of the transverse valleys."

Osborn, 1921: The above type description (1916 [1917]) was written first and is placed first in Hay's Bibliography (March 8, 1921). On June 1, 1917, Hay published another description from which we take the following facts and citation:

HAY, 1917.3, P. 219.—The specimen was found about 1908 near McPherson, Kansas, in a sand pit, at a depth of about 35 feet, in section 34, township 19 north, range 3 west. The region about McPherson is covered by deposits which the author attributes (p. 221) to the Sheridan, or Equus, beds, an early phase of the Pleistocene. "We have in this tooth, therefore, evidence that the bunolophodont mastodons continued on into the Pleistocene." This the author confirms by reference to other specimens believed to be of the same geologic age. The *type*, a left third lower molar, possesses "five cross-crests and a large talon. . . . Outer ends of valleys closed by buttresses and forming trefoils on wear. Inner ends of valleys partially closed by accessory conules. . . . The length of the tooth is 217 mm.; its width at the first cross-crest, 83 mm.; at the fourth, 85 mm. It will be seen from the measurements and the figures (pl. 26, figs. 1, 2) that the tooth is a long and relatively narrow one. There are present six cross-crests, the hindermost one being something more than a talon. The inner and the outer halves of each crest are separated by a narrow but very deep cleft. Each half of each crest may be regarded as composed of two cones, the principal one and another nearer the mesial cleft. The latter does not rise quite as high as the principal cone and is separated from the latter by a cleft."

GEOLOGIC AGE, OSBORN, 1923. The early Pleistocene age of this specimen is important if Hay is correct in attributing the type to the Sheridan formation which with Hay we have placed in the Aftonian, or *1st Interglacial* time. Such a recent age seems improbable when we consider the relatively primitive condition of the type grinder and the relatively progressive condition of *Tetralophodon* (*Morrillia*) *barbouri* of Middle Pleistocene age. We therefore regard this tooth as of Middle(?) Pliocene age.

PHYLETIC RELATIONSHIP.—Hay (1917.3, p. 220) erroneously compares the type tooth with Leidy's species '*M.*' *floridanus* of the Florida Pliocene, and observes that the latter is more primitive in possessing single trefoils and in its four and a half crested M_3; he also compares the tooth with the species *Gomphotherium* [= *Cordillerion*] *tropicus* Cope of the Blanco Pliocene and remarks that in *Tetralophodon elegans* there is a greater subdivision of the principal cones and a larger number of accessory conules. Osborn's opinion is that the *type* of *G. elegans* represents a species somewhat more progressive than *Tetralophodon campester* and that the referred specimen (Fig. 332, upper) belongs to the more primitive genus *Trilophodon*.

Trilophodon (?Tetralophodon) brazosius[1] Hay, 1923

Brazos River, near San Felipe, Texas. Probably of Pliocene age.

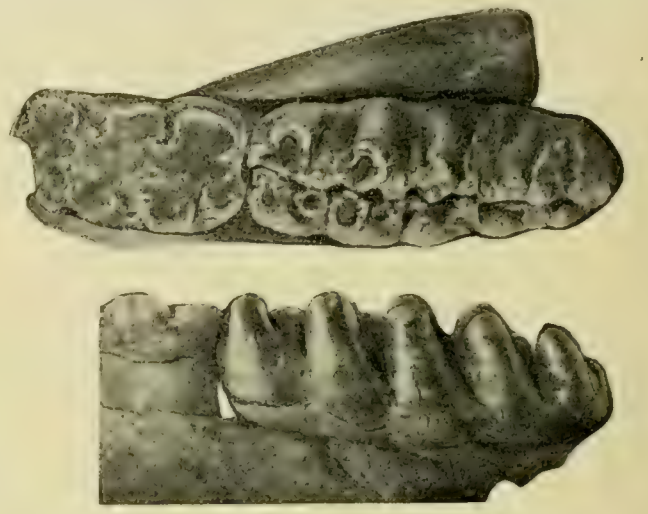
The species '*Anancus*' *brazosius* Hay, 1923, is difficult to determine without an examination of the type specimen (Fig. 333), but it appears to be referable to the genus *Tetralophodon*[1], in a specific stage characterized by transverse cones in M_2 and double trefoils in the five crested M_3.

Anancus brazosius Hay, 1923. "Characteristics of Sundry Fossil Vertebrates." The Pan-American Geologist, Vol. XXXIX, pp. 112–114. TYPE.—Part of the right ramus of a lower jaw in the Agricultural and Mechanical College, College Station, Texas. HORIZON AND LOCALITY.—Brazos River, near San Felipe, Texas. Probably of Pliocene age. TYPE FIGURE.—Hay, *op. cit.*, 1923.2, Pl. VIII, figs. 1 and 2.

TYPE CHARACTERS.—(Hay, 1923.2, pp. 112, 113): "The jaw and teeth are well fossilized and the teeth are beautifully preserved; only the front end of the second molar is damaged slightly. The second molar is worn on all of the crests; the third molar on only the first and second crests. The second molar presents three crests and a talon which at its inner end is so large as to suggest a fourth crest. In the worn condition of this tooth trefoils appear at both the outer and the inner ends of the crests. The length of the tooth is 130 mm.; its width, 76 mm."

"The hindermost molar presents five cross-crests and a rear tubercle. The outer ends of the valleys are blocked by accessory cusps which cling to the main cusps. On wear there are produced trefoils. On the inner side of the tooth trefoils would, on further wear, appear on two or three of the front crests. The main cusps of the crests are columnar and well spaced. The enamel is mostly smooth. A thin coat of cement is found in the valleys and on the bases of the cusps. The length of the tooth is 220 mm.; the width, 85 mm. The pulp cavity is yet large. The mandible appears to have been slender. The depth at the front of the hinder molar is 133 mm.; the thickness, 125 mm."

(Hay, *op. cit.*, cf. p. 113): These teeth resemble *Gomphotherium elegans*, now to be known as *Anancus elegans*, with specific differences only. "The figures (pl. viii) show the cusps of *Anancus brazosius* to be of different form and to be not so closely spaced. The hindermost molar of *A. elegans* appears to be more abundantly supplied with accessory cusps than the Brazos species. In the writer's description of *A. elegans*, he referred to this species an upper second molar that had been found near Waco, Texas. It is possible that this molar really belongs to the species described in this paper."



TYPE OF TETRALOPHODON[1] BRAZOSIUS

Fig. 333. Part of right ramus of lower jaw of *Anancus brazosius* Hay, containing type second and third inferior molars, r.M_{2-3}, crown and internal aspects. One-fourth natural size. After Hay, 1923.2, Pl. VIII, figs. 1 and 2 (cf. p. 120).

Osborn, 1926: In the present Memoir the type of *Gomphotherium elegans* Hay has been transferred to *Tetralophodon elegans*. Accordingly in the present Memoir *Anancus brazosius* is referred to *Tetralophodon*[1] (*?Trilophodon*) *brazosius* Hay; it is difficult to identify this type third inferior molar of *A. brazosius*, but on the whole it presents a close resemblance to the third inferior molar of *T. campester* (Fig. 308D), also to that of *T. elegans* Hay (Fig. 332).

Osborn, 1934: The incomplete fourth ridge-crest of M_2 resembles *Trilophodon*[1] rather than *Tetralophodon*.

9. TETRALOPHODON FRICKI SP. NOV., FROM THE PLIOCENE OF TEXAS

In 1930, under the direction of Mr. Childs Frick, a fine palate of a mastodon was unearthed in northern Texas, a few miles north and east of Clarendon. No other remains were found in association with it. The specimen was first described by Frick in 1933, in his article "New Remains of Trilophodont-Tetrabelodont Mastodons," as follows: "(?) *Tetralophodon* species. From Northern Texas."

After prolonged examination, the present author regards this specimen as representing a new and distinct species, of more primitive character than the classic *Tetralophodon campester* of Cope and agreeing more closely with the recently described *Tetralophodon bumiajuensis* Maarel of Java. It is therefore a most welcome addition to our knowledge of the Tetralophodonts.

[1] Osborn (1935) now refers this specimen to *Trilophodon* because of the three-crested condition of M_2.

Tetralophodon fricki sp. nov.

Figures 308B, 334, 335

From northern Texas, a few miles north and east of Clarendon. Lower to Middle Pliocene.

The type (F:A.M. 23342), consisting of the basicranial region, complete palate, partly worn second and third superior molars of both sides, superior tusks with broad external enamel band, four complete ridge-crests on the second superior molars, five complete ridge-crests on the third superior molars, is somewhat doubtfully referred to *Tetralophodon*. The author takes great pleasure in naming this species after his friend Mr. Childs Frick, in further recognition of his fine explorations and researches in the Pliocene of North America.

The first bibliographic reference to this type is that of Frick (1933, p. 607), as follows: "(?) *Tetralophodon* species. From Northern Texas. The inferior area of a skull with enamel-banded tusks and Tetralophodont dentition, obtained from a deposit in northern Texas, is interpreted as of a Tetralophodont-Longirostrine. EXAMPLE.—Partial skull with enamel-banded tusks and m^2-m^3, dorsal half of cranium missing. F:A.M. 23342. Figured this paper, *Figs. 12 and 23B*." Reproduced herewith (Fig. 334) is Frick's figure (Fig. 12) of the palate.

The accompanying figures of the superior molar teeth and the comparative photographs of the palate of *Tetralophodon fricki* and *Platybelodon grangeri* (Fig. 335) clearly exhibit the parallelism of these species in the possession of a four-crested second superior molar.

The superior molars (M^2, M^3) exhibit central conules (CCC) in the valleys between the proto-, meta-, trito-, and tetartolophs; conules are an unusual feature in *Tetralophodon*, the central conules being usually absent; these conules cannot be interpreted as detached anterior trefoil spurs; they appear on the entoconelets of the four anterior crests. The ridge-crests (47c mm.) in the worn M^2 are about as lofty as those in M^2 of *Tetralophodon longirostris* (cast Amer. Mus. 10484). In M^3 the second ridge-crest is estimated as 70 mm. in length. The 5+ crested third superior molars exhibit the characteristic forward inclination of each of the five crests. This five-crested condition agrees with the five-crested condition of *Tetralophodon bumiajuensis* of Java and is more primitive than the six-crested condition of *T. campester*.

In this and other respects the type of *Tetralophodon fricki* appears to be a smaller and more primitive form than the type of *T. campester* and is possibly referable to an earlier geologic horizon than the Republican River which yielded Cope's classic type, *T. campester*. The principal comparative measurements are as follows:

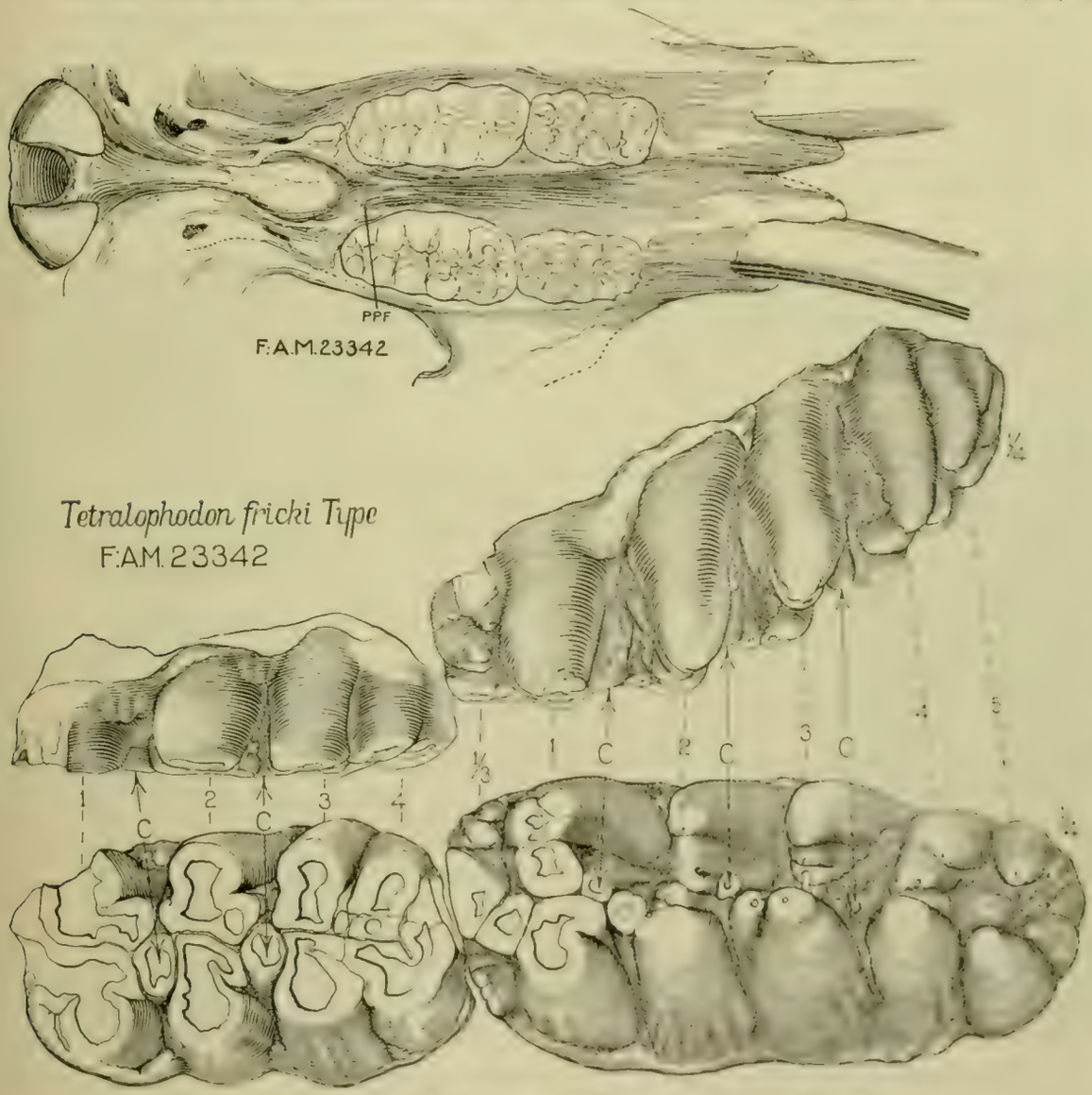


Fig. 334. TYPE PALATE AND DENTITION OF TETRALOPHODON FRICKI SP. NOV.

(Upper) Palatal aspect of the type (F:A.M. 23342), compare Frick, 1933, fig. 12, one-seventh natural size.

(Lower) Second and third superior molars of the left side, l.M^{2-3}, one-fourth natural size.

Observe characteristic four-crested l.M^2 with prominent central conules (CC) and posterior trefoils on proto- and metalophs. The posterior grinders exhibit two rudimentary and five well-developed ridge-crests, six altogether; also incipient anterior (⅓) and posterior (¼) ridge-crests; small central conules (CCC), rudimentary entotrefoils on the three anterior crests; relatively more hypsodont than *Tetralophodon longirostris*.

	Tet. fricki Type (F:A.M. 23312)	*Tet. campester* Type (A.M. Cope Coll. 8527)	*Plat. grangeri* Ref. (A.M. 26479)
R.M²			
Length	128 mm.	118 mm.	128 mm.
Breadth	73	75	67
Index	57	64	52
Height of tritoloph	47e	20+	55+
R.M³			
Length	182	195	230
Breadth	89	80	80
Index	49	41	35
Height of metaloph	70	67	85
Length of right superior tusk on curve to border of alveolus	640	790+(1000e)	Not present
Left, ditto	590	Not present	Not present
Length, condyle to premaxillary symphysis	875	900e	920
Transverse occipital condyle	184	199	200

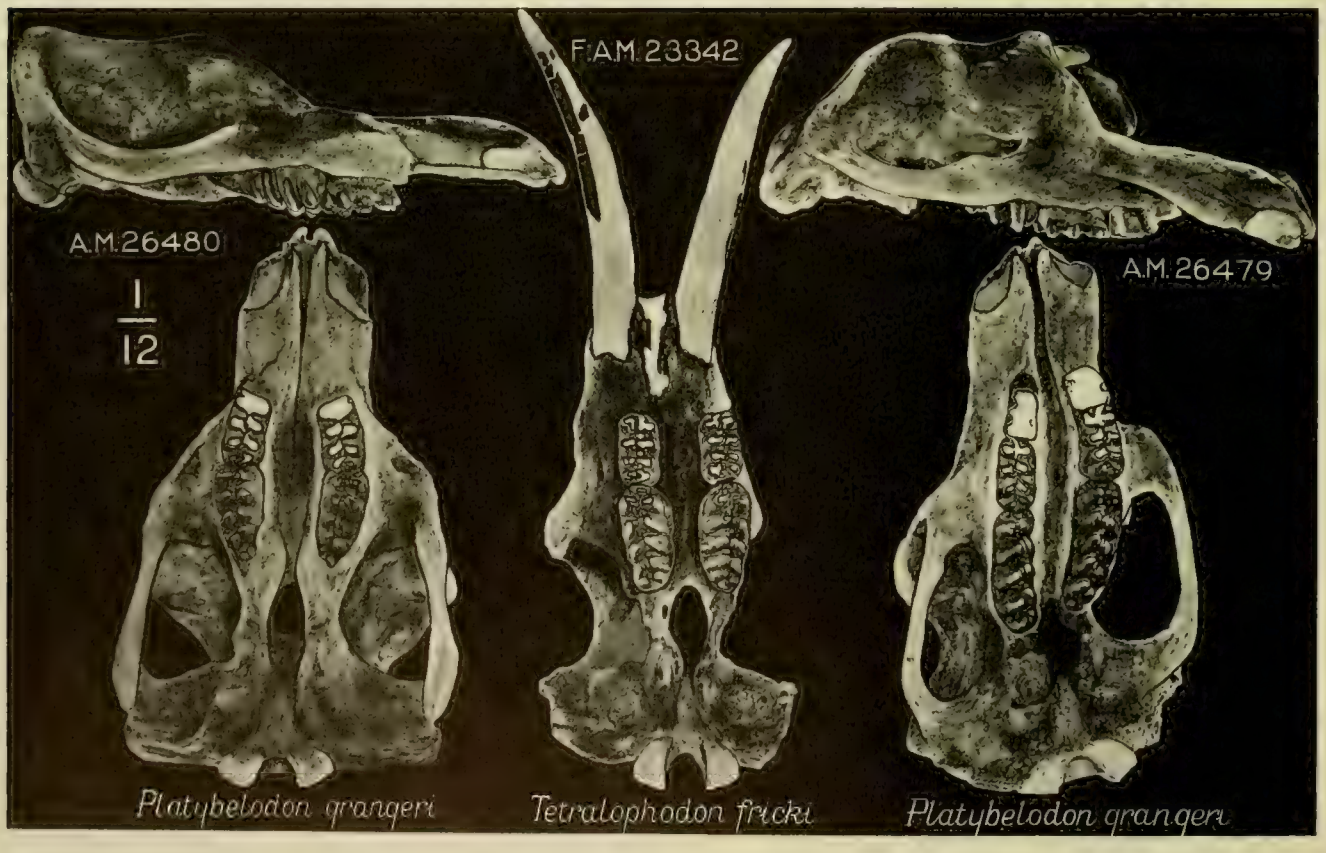


Fig. 335. Tetralophodon and Platybelodon Crania

One-twelfth natural size

Tetralophodon fricki (center) is a primitive member of the Tetralophodontinæ of Maarel.

Platybelodon grangeri, the 'flat-tusker' of the Gobi Desert, is a very progressive member of the serridentine subfamily Platybelodontinæ Borissiak.

Observe the somewhat similar palatal aspects but wholly dissimilar pattern of the molar ridge-crests.

10. FINAL HYPSODONT SUBGENERIC STAGE OF TETRALOPHODON, NAMELY, T. (MORRILLIA) BARBOURI, MIDDLE PLEISTOCENE

Subgenus: **MORRILLIA** Osborn, 1924

Original reference: Osborn, Amer. Mus. Novitates, No. 154, Dec. 24, 1924, p. 1 (Osborn, 1924.634).
Genotypic species: *Tetralophodon barbouri* Osborn, 1921.

Subgeneric Characters.—Complete doubling of trefoils; lophs elevated, hypsodont, closely appressed; (?) pro-protolophid crest nearly completed, lophs increasing from seven to eight; thick coating of cement in valleys. As compared with the primitive subgeneric stage *Lydekkeria* of the Mio-Pliocene, this final Middle Pleistocene stage of *Tetralophodon* has made remarkable progression. Unfortunately the subgenus rests at present on two grinding teeth; consequently we must be on our guard against positively placing it as a terminal member of the phylum *Tetralophodon*.

This new subgenus *Morrillia* was named in honor of the Honorable Charles H. Morrill, "in recognition of his generous support of the field expeditions and collections made under the direction of Professor Erwin H. Barbour which have yielded such astonishing results, especially in the subfamily Longirostrinæ, including the *Trilophodon* and the *Tetralophodon* [Tetralophodontinæ] of Nebraska."

Uncertain Phyletic Relations. Examination of the diagrams (Figs. 308, 329) certainly appear to show that the grinding teeth of *Tetralophodon campester* are evolving in a direction which naturally would lead into *T.* (*Morrillia*) *barbouri*. As indicated above, *T. barbouri* may represent a distinct generic stage of *Tetralophodon* to which the subgeneric name *Morrillia* has been applied (Osborn, 1924.634), distinguished by marked hypsodonty, cement, and 7½ to 8⅓ crests. The affinity of this extremely progressive stage to the genus *Tetralophodon*, rather than to the genus *Stegomastodon*, e.g., *S. mirificus*, is indicated by the *double* trefoils, internal and external, on the superior ridge-crests, as clearly shown in figure 308F, which may be contrasted with the *quadruple* trefoils of the most progressive stage of *Stegomastodon*, namely, *S. aftoniæ*. In *Tetralophodon* (*Morrillia*) *barbouri* the internal and external cones are opposite; in *S. arizonæ* (Fig. 649) they are strongly alternating.

In *Tetralophodon* (*Morrillia*) *barbouri* the cones are strongly hypsodont, valleys filled with cement: in *Stegomastodon arizonæ* the cones are subhypsodont, valleys less filled with cement.

Consequently *Tetralophodon* (*Morrillia*) *barbouri* may not be regarded as related to the phylum *Stegomastodon*: it appears certainly to belong to the phylum *Tetralophodon*.

Tetralophodon (Morrillia) barbouri Osborn, 1921

Figures 308F, 329D, E, 337, 339, and 349

Cambridge, Furnas County, Nebraska, Middle Pleistocene.
Syn.: *Tetralophodon precampester* Osborn, 1923.

This extremely progressive species was made the type (Osborn, 1924.634, p. 1) of the subgenus *Morrillia*, distinguished from the genus *Tetralophodon* by the extreme hypsodonty of the crests, the heavy coating of cement, the multiplication of the crests to M 3 $\frac{1/2\text{-}2\text{-}8\text{-}1/2}{}$ as compared with M 3 of *T. campester*, namely, M 3 $\frac{1/2\text{-}5\text{-}1/2}{1/2\text{-}5\text{-}1/2}$.

The specific name *Tetralophodon barbouri* was given by Osborn in 1921 (1921.515) in honor of Professor Barbour of the University and Geological Survey of Nebraska, to whom the writer was indebted for the privilege of describing this specimen, and to whom palæontology is indebted for greatly increasing our knowledge of the American Longirostrines and other bunomastodonts. As shown in the comparative figure (Fig. 329D, E), this species is by far the most progressive of all the Tetralophodonts. With its seven and a half to eight and a third crests and partial coating of cement, its evolution is much beyond that of *T. campester*, with six total crests on the superior grinders and without cement. The intermediate molars are unknown, but it is safe to infer that the ridge formula was: M 2 4, M 3 $^{1/2\text{-}2\text{-}8\text{-}1/2}$.

Tetralophodon barbouri Osborn, 1921. "The Evolution, Phylogeny, and Classification of the Proboscidea." Amer. Mus. Novitates, No. 1, January 31, 1921, pp. 9 and 10. Type Specimen and Locality.—"Grinding tooth with double trefoils, seven and a half to eight crests, and cement;" Neb. Mus. 4-22-6-16. The type locality of this tooth according to the

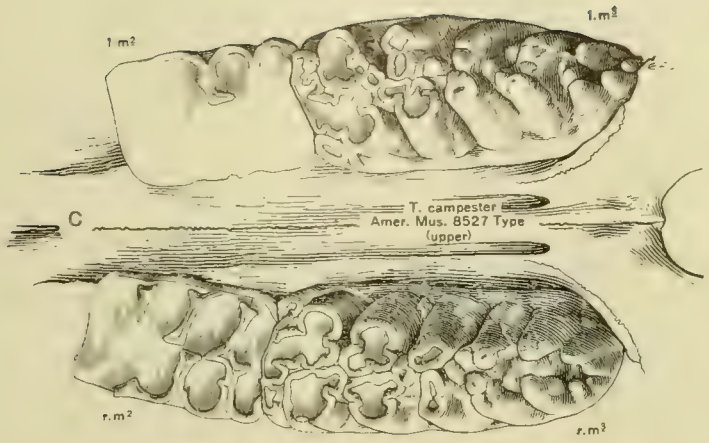


Fig. 336. Type palate of *Tetralophodon campester* Cope. One-fourth natural size.

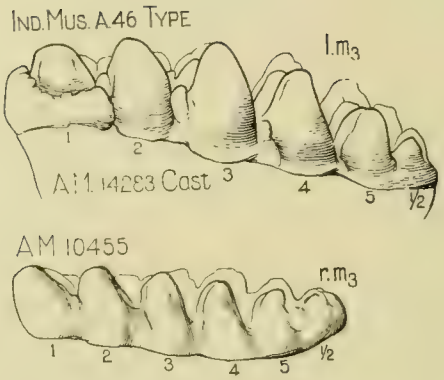
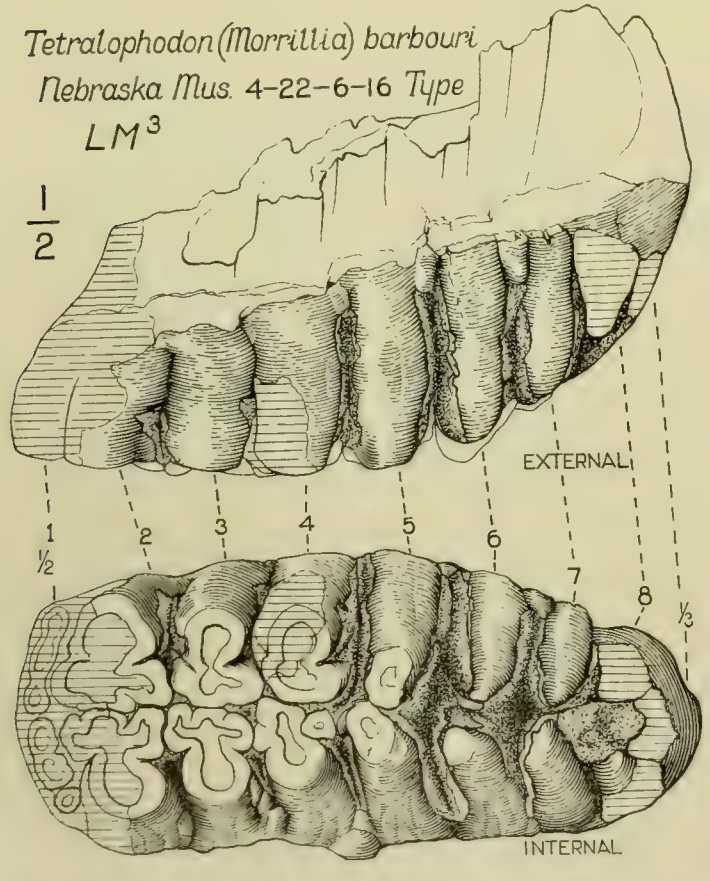
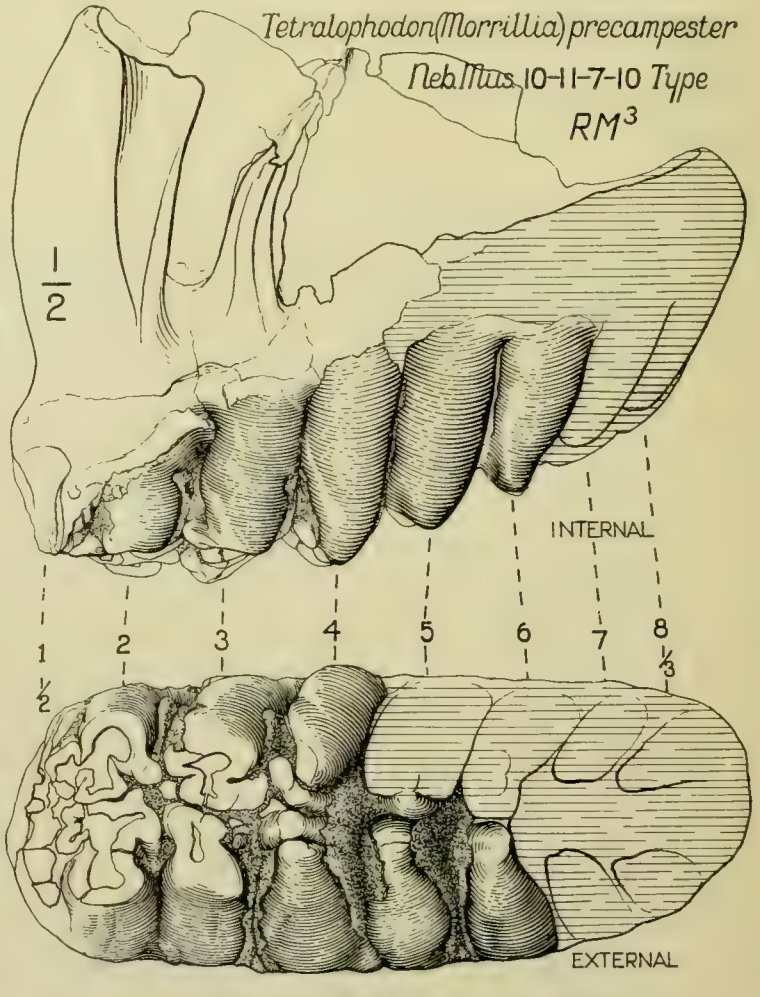


Fig. 338. Type of *Tetralophodon punjabiensis* (upper) and of *T. longirostris* (lower). One-fourth natural size.



Type of Tetralophodon (Morrillia) barbouri

Fig. 337. Type left third superior molar of *Tetralophodon* (*Morrillia*) *barbouri* Osborn, 1921 (Neb. Mus. 4-22-6-16), one-half natural size. This final ½-2-8-⅓ (=8⅓) ridge-crested stage, extremely hypsodont, presents a very marked progression upon the relatively brachyodont type of *T. longirostris* Kaup (cf. Fig. 308A).



Tetralophodon (Morrillia) barbouri Ref.

Fig. 339. Type right third superior molar of *Tetralophodon precampester* Osborn, 1923 (Neb. Mus. 10-11-7-10), restored and redrawn in comparison with the type of *T.* (*Morrillia*) *barbouri*. *T. precampester* is a synonym of *T.* (*M.*) *barbouri*, namely, it has ½-2-8-⅓ (=8⅓) ridge-crests. crest ½ being an imperfect cingulate ridge half developed. One-half natural size.

Nebraska State Museum records is Cambridge, Furnas County, Nebraska. TYPE FIGURE.—Osborn, 1924.634, p. 2, fig. 1—figures 308F, 329D, and 337 of the present Memoir.

TYPE DESCRIPTION.—(*Op. cit.*, 1921.515, p. 10): "A second new species is the *Tetralophodon barbouri*, of which the type (Neb. State Mus. No. 4.22.6.16) is a grinding tooth with double trefoils, seven and a half to eight crests, and cement; thus advanced much beyond *T. campester* with six and a half crests on the superior grinders, without cement. . . . [p. 9] In all Pliocene species observed the intermediate molars are four-crested; hence they fall within the genus *Tetralophodon* Warren [1852], Falconer [1847]. From the Middle Miocene apparently to the close of the Middle Pliocene there was a steady addition of crests to $m\frac{3}{3}$, rising from four and a half crests in the Middle Miocene (*T. angustidens*) to seven and a half crests in the Middle Pliocene [Middle Pleistocene] (*T. barbouri*, new species). At the same time the crests become subhypsodont partly coated with cement."

Osborn, 1923: The type of this species might be mistaken for a specimen of *Anancus*, but it is readily distinguished (1) by the extreme hypsodonty of the lophs, (2) by the double trefoils of the surface of the crown as compared with the quadruple trefoils in the corresponding molar teeth of *Stegomastodon*, (3) also as shown in figure 337 of this Memoir, by opposition of the internal and external cones instead of alternation as in *Stegomastodon* (Fig. 643).

11. SUMMARY OF EVOLUTION AND MIGRATION

TETRALOPHODON.—The strikingly progressive evolution of the posterior grinders of *Tetralophodon*, from the low-crowned, brachyodont grinders of *T. longirostris* to the lofty, hypsodont, and heavily cemented grinders of *T.* (*Morrillia*) *barbouri*, is beautifully displayed in the diagrammatic figures (Figs. 308 and 329).

LYDEKKERIA.—The hypothetical Miocene stage *Lydekkeria*, with single trefoils and incipient double trefoils, also incomplete fourth crest on M 2, still awaits verification.

MORRILLIA.—The final hypothetical hypsodont stage *Morrillia* is still represented by only two third superior grinding teeth (Figs. 337, 339), appropriately dedicated to Prof. Erwin H. Barbour, in further recognition of his fine life work in revealing the Proboscidean world of ancient Nebraska.

From the limited evidence now at hand, it would appear that *Tetralophodon* became rare in Eurasia early in Pliocene time but lingered until Middle Pleistocene time on the ancient flood-plains of Nebraska. The progressive hypsodonty of *Morrillia* is doubtless an adaptation to the increasing aridity and hardness of the browsing and partly grazing diet.

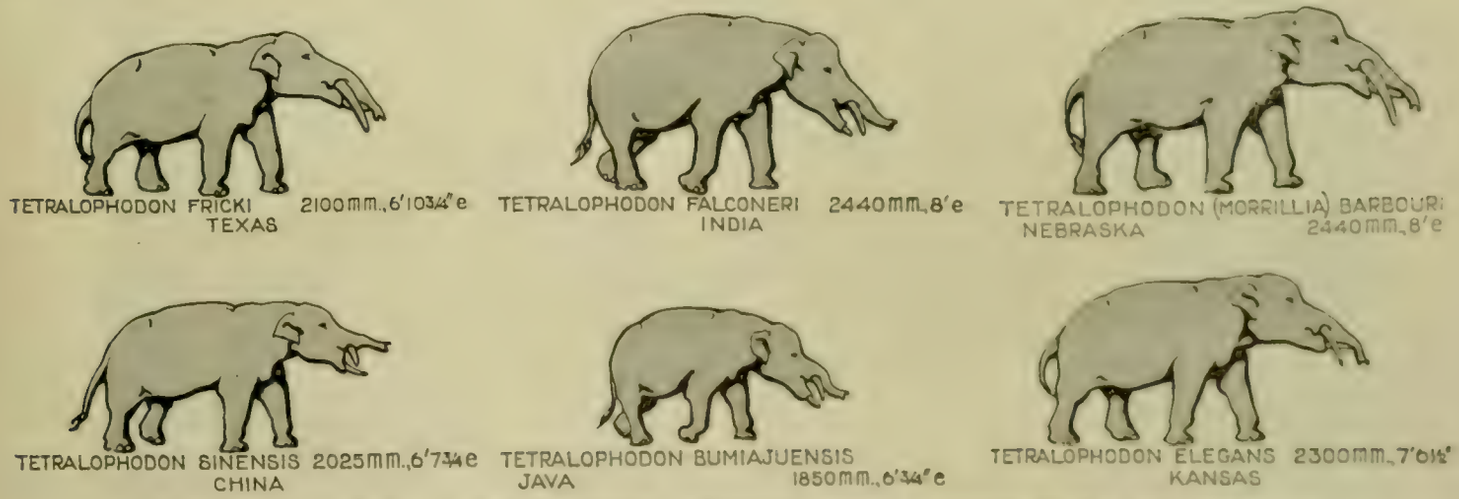


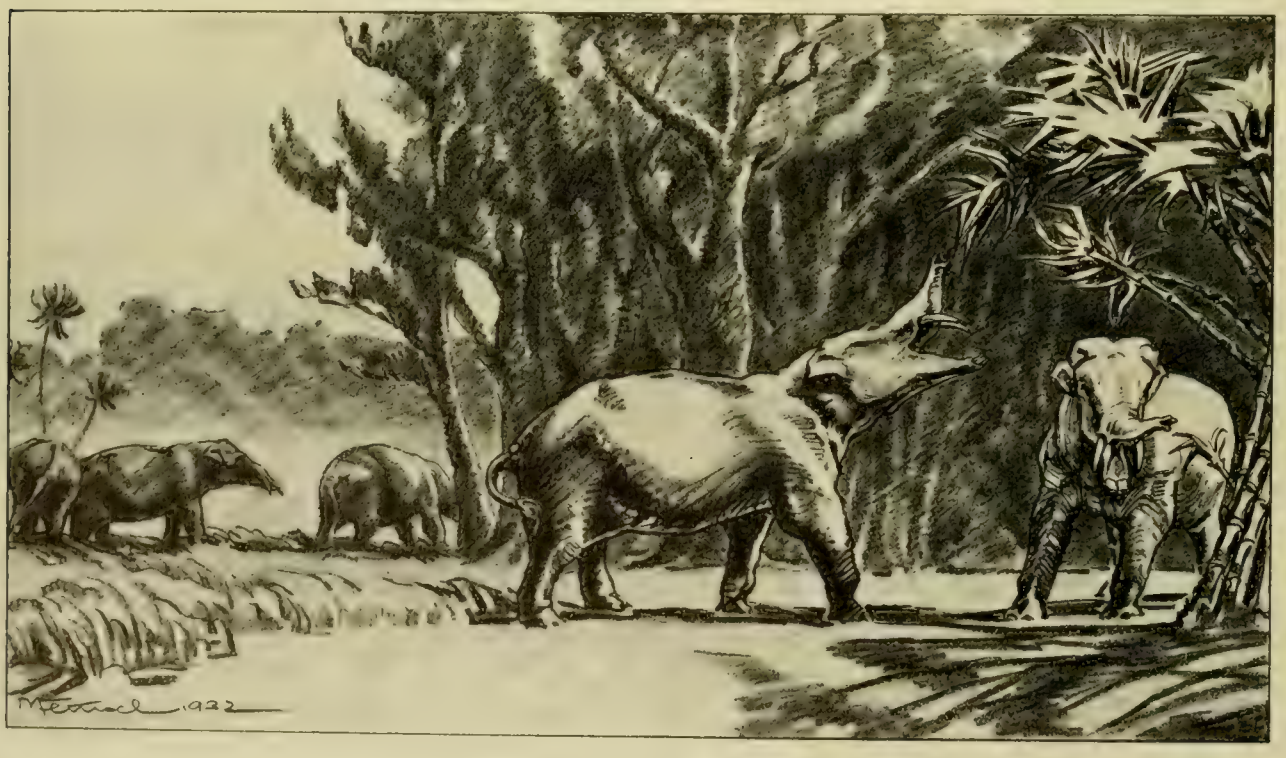
Fig. 339a. WORLD MIGRATION OF TETRALOPHODON. RESTORATIONS TO A ONE-HUNDREDTH SCALE BY MARGRET FLINSCH, UNDER THE DIRECTION OF HENRY FAIRFIELD OSBORN

(Left) *Tetralophodon* (*Lydekkeria*) *sinensis* and *T. fricki*; (center) *T. bumiajuensis* and *T.* (*Lydekkeria*) *falconeri*; (right) *T. elegans* and *T.* (*Morrillia*) *barbouri*.

OCALIENTINUS (SERRIDENTINUS) FLORIDANUS LEIDY

Restoration to a one-fiftieth scale, by Margret Flinsch, December, 1932, under the direction of Henry Fairfield Osborn

Fig. 340. Characteristic and abundant serrate-toothed mastodont of the Lower Pliocene Alachua formation of Florida, with associated herd of Hipparions (*Hipparion ingenuum*) and of amphibious rhinoceroses (*Teleoceras proterus*). A similar stage, *O.* (*Ser.*) *republicanus*, occurs in the Republican River formation of northwestern Kansas.



SERRIDENTINUS PRODUCTUS COPE

Restoration to a one-fiftieth scale, by Margret Flinsch, December, 1932, under the direction of Henry Fairfield Osborn

Fig. 341. Drawn after the model (Fig. 365) of restored skeleton (Figs. 371, 372) from the base of the Clarendon formation, Lower Pliocene of Texas, collected by the American Museum Expedition of 1899.

This uppermost Miocene stage of Serridentine evolution occurs abundantly in the lower levels of the Santa Fé marls (Mio-Pliocene) of New Mexico, from which the type mandible (Fig. 367) was described by Cope in the year 1875. The associated fauna includes two canids (*Aelurodon wheelerianus* and *Hemicyon ursinus*); a primitive equine (*Merychippus calamarius*), and one progressive equine (*Hipparion gratum*); two cameloids (*Procamelus gracilis* and *Pliauchenia humphreysiana*); one procervid (*Palæomeryx teres*).

Chapter X

HISTORY OF THE NEW FAMILY SERRIDENTIDAE.[1] SERRATE-TOOTHED MASTODONTS. ORIGIN AND GEOGRAPHIC DISTRIBUTION OF THE MEDIUM-JAWED SERRIDENTINUS OF EUROPE, ASIA, AND NORTH AMERICA

Distinctions between the newly recognized genus Serridentinus, formerly confused with Trilophodon. First appearance in the Miocene of central Europe. Discovery in Mongolia, China, and India. Leidy observes occurrence in the southeastern United States (Florida). Cope observes New Mexico and Texas stages. Osborn describes new species from Florida, South Carolina, Guatemala, and Mongolia. Discovery of the serridentine flat-tusker Platybelodon and dredge-tusker Torynobelodon; of the South American Notiomastodon.

1. European forest origin of the Serridentinæ. Migration into North America, and apparent division into forest-dwelling and arid plateau-dwelling forms, persisting into the Upper Pliocene.

   Clear separation of *Serridentinus* from *Turicius*, *Trilophodon*, and *Tetralophodon*, by characters of the tusks and of the grinding teeth.

2. Order of discovery and description of thirty-four species of the Serridentinæ, four of the Platybelodontinæ, and two of the Notiomastodontinæ, during the period 1873–1935.

3. Synopsis of subfamily, of generic, and of specific characters. Ascending phylogenetic order of the species.

4. Eurasiatic species: *Serridentinus subtapiroideus*, *S. mongoliensis*, *Ocalientinus* (*Ser.*) *florescens*, *S. gobiensis*.

5. More progressive plains-loving species of the mid-western states (*Serridentinus progressus*, *S. proavus*, *S. productus*). Skeleton compared with that of *Trilophodon giganteus*.

6. Progressive forest-loving species of northwestern Kansas, *Ocalientinus* (*Serridentinus*) *republicanus*; of the Lower Pliocene of Florida, *O.* (*S.*) *floridanus*, *O.* (*S.*) *bifoliatus*, also *O.* (*S.*) *floridanus leidii*; of the Pliocene of South and North Carolina, *O.* (*S.*) *obliquidens*.

7. Progressively long-crowned plains- and desert-loving species of the western and southwestern states (*Serridentinus anguirivalis* and *S. nebrascensis* of Nebraska, *S. serridens* and *S. serridens cimarronis* of Texas, *Serbelodon*(?) *præcursor*, Pliocene of Mt. Blanco). Also the species *S. brewsterensis* of the Lower Pliocene of Florida; *S. guatemalensis* of the Central American plateau, Upper Pliocene.

8. Recently described genera (*Ocalientinus*, *Serbelodon*) and species in the Frick Collection.

9. Discovery of two short-jawed, blunt shovel-tuskers (*Serbelodon* and *Trobelodon*) of Serridentine relationship.

10. Primitive and progressive Serridentinæ of the Siwaliks of India.

11. Serridentines of Japan and China, Miocene and Pliocene.

12. Flat-tuskers or Platybelodontinæ of central Asia and western America (*Platybelodon* and *Torynobelodon*).

Appendix: *Serridentinus filholi* Frick and *S. nebrascensis* Osborn.

(May, 1935) Since 1926, when the main portion of the present Chapter X was completed, nineteen new species of 'Serridentines' and 'Platybelodontines' have been discovered and described from North America, India, Mongolia, western Asia, and southwestern United States, as listed on pages 384, 385. These new species (1928–1935) amplify the geographic range and strongly confirm the separation of this subfamily, also of the subfamily Platybelodontinæ. Two species (*Serridentinus simplicidens* and *Mastodon obscurus*) are now redetermined as *Trilophodon*. *Trilophodon progressus* and *Stegomastodon nebrascensis* are found to belong in the subfamily Serridentinæ. Important genera (*Torynobelodon* of Nebraska, see Chap. VIII, p. 338, and this chapter, p. 470), also *Ocalientinus*, *Serbelodon*, and *Trobelodon* of the Frick Collection from New Mexico, Texas, Nebraska, and Mexico) are added. See Appendix to present Volume I for description of *Gomphotherium*? [*Ocalientinus*] *emmonsi* Hay, 1930.

(July, 1935) As described and figured (Pl. XII) in the Appendix of the present Volume I, the new South American genus *Notiomastodon* Cabrera proves to be a typical member of the new family Serridentidæ; see also description and figures in Chapter XII, and Pl. IX of this chapter (X); for the reception of this genus, the present author is making the new subfamily Notiomastodontinæ.

1. EUROPEAN FOREST ORIGIN AND SEPARATION FROM OTHER TRILOPHODONTS

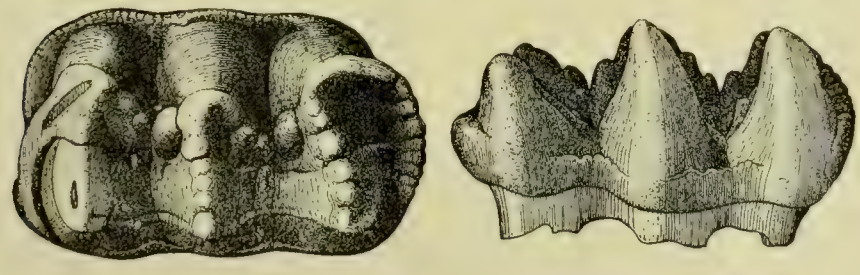
These 'serrate-toothed mastodonts' rarely occur in the same geologic formations in association with *Trilophodon*, although in both France and America they are frequently found in the same geographic regions and in the same periods of geologic time. Consequently, as explained in Chapter II, we regard these medilongirostral or medium-jawed 'Serridentines' as examples of *local adaptive radiation;* arising in western Eurasia as forest-dwelling and swamp-dwelling forms, they gave rise to forest-dwelling and plateau-dwelling forms in America. As they occur together in the Mio-Pliocene of New Mexico the skeleton of *Serridentinus* shows a *marked inferiority in size* to that of *Trilophodon* (see Fig. 372 of the present Memoir).

[1]For definition of the new family SERRIDENTIDÆ, also new subfamily Notiomastodontinæ, see Appendix of the present Volume I.

MEASUREMENTS

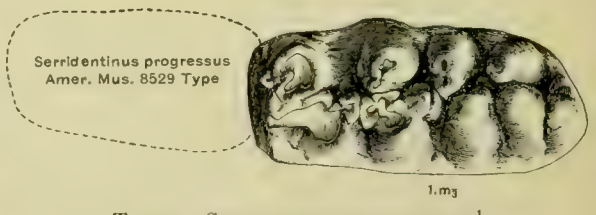
Trilophodon giganteus	*Serridentinus productus*
Estimated shoulder height, 2440 mm. = 8 ft.	1682 mm. = 5 ft. 6¼ in.

ORIGIN OF SERRIDENTINUS.—With their profound initial differences in molar tooth structure it is obvious that the Serridentinæ sprang not from the progressive *Phiomia osborni*, in which central conules are displayed, but from a more primitive species of unknown African mastodont, in which central conules are absent. In many other features the phylum *Serridentinus* is related to primitive members of the Bunomastodontidæ, especially in the superior enamel-banded incisive tusks and in the inferior broadly flattened incisive tusks without enamel. In still other characters the Serridentinæ closely parallel the phylum *Trilophodon*, namely, in the permanently three crested 'intermediate molars,' Dp 4-M 2; in fact, in the third inferior molar, M_3, certain of the well-worn grinders of *Serridentinus* so closely resemble well-worn grinders of *Trilophodon*, that it is not surprising that keen observers like Cope failed to separate these two phyla. Finally there is a strong resemblance between the grinding teeth of primitive species of *Serridentinus*, of New Mexico and Florida, and *Mastodon* (*Bunolophodon*) *subtapiroidea* Schlesinger [=*Serridentinus subtapiroideus*] of Eibiswald, Styria; there are also other Miocene specimens of Europe which show relationships to *Serridentinus*.



TYPE OF SERRIDENTINUS SERRIDENS

Fig. 342. Type second superior molar of the right side, r.M^2, of *Mastodon serridens* Cope, one of the genotypic species of the genus *Serridentinus* Osborn, of the subfamily Serridentinæ Osborn, showing serrate spurs springing from the internal conelets. Crown and inner views. Four-ninths natural size.



TYPE OF SERRIDENTINUS PROGRESSUS[1]

Fig. 343. Type third inferior molar of the left side, l.M_3, of *Trilophodon* [*Serridentinus*] *progressus* Osb., showing the presence of ectotrefoil spurs springing from the ectoconelets, as contrasted with the mesotrefoil spurs springing from the mesoconelets.

TURICIUS AND SERRIDENTINUS.—One of the most interesting results of the prolonged research in preparation for this Memoir is the discovery of two clearly distinguishable phyla of mastodonts (*Turicius* and *Serridentinus*) which by all previous investigators both in Europe and America had been confused with the phylum *Trilophodon*.

The types of the genus *Turicius* have been clearly described above in Chapter VII. In the present chapter it is shown that the grinding teeth, e.g., of *Mastodon* (*B.*) *subtapiroidea* of the Lower Miocene lignites (Figs. 351, 352), widely differ from those of *Trilophodon* and strongly resemble those of *Serridentinus*, as seen in a comparison of figures (Fig. 350); it is possible that *Turicius* and *Serridentinus* arise from a similar stock not unlike *Serridentinus subtapiroideus*. The evolution of the true *Turicius* phylum, however, is entirely distinct, leading into sharply crested forms such as *T. virgatidens*, while the *Serridentinus* phylum is (A) increasingly Serridentine, ending in *Ocalientinus* (*Ser.*) *floridanus*, or (B) more crested, ending in *S. guatemalensis*.

[1]This species, originally described by Osborn (1923.601, p. 3) as *Trilophodon progressus*, now proves to be *Serridentinus progressus*.

PLATE IX

Restoration of the South American Serridentine *Notiomastodon ornatus* Cabrera, one twenty-seventh (left) and one-fiftieth (right) natural size. By Margret Flinsch, 1935. This restoration is based on the adolescent type mandible (upper figure, one-fourth natural size) in the Buenos Aires Museum (Buenos Aires Mus. 2157; cast Amer. Mus. 27797) and a referred adult tusk (La Plata Mus. 8–45, see figure 557B of the present Memoir).

SERRIDENTINUS AND TRILOPHODON. -There are also several pronounced characters which clearly separate the species assembled in the subfamily Serridentinæ from those assembled in the subfamily Longirostrinæ. But the outstanding or salient feature is observed in the fundamental structure of the superior and inferior grinding teeth: *First*, the *central conules* observed in *Phiomia osborni* and in all species of *Trilophodon* are *entirely absent* in *Serridentinus; second*, these central conules are functionally replaced in *Serridentinus* by *crests* which arise on the sides of the *superior internal* cones and on the *inferior external* cones; *third*, these internal and external crests subdivide into two, three, four to six (Fig. 342) smaller conelets, which give rise to a serrated aspect. Consequently these animals are appropriately termed the 'serrate-toothed mastodonts' or Serridentinæ.

Turicius	*Serridentinus*	*Trilophodon*
Conules retrogressive in the valleys between the crests.	No central conules.	Strong central conules.
Trefoil crests from ecto- and entoconelets feeble.	Trefoil crests from ecto- and entoconelets strong, progressive.	Trefoil crests from mesoconelets uniting with conules.
Superior incisive tusks, I^2, oval in section, with sharply defined enamel band, except in *T. virgatidens*.	Tusks, I^2, laterally compressed, with broad enamel band.	Tusks, I^2, rounded, with enamel band.
Inferior incisive tusks, I_2, straight, suboval in section, without enamel, undergoing progressive reduction.	Tusks, I_2, large, horizontally flattened, not reaching the ground.	Tusks, I_2, greatly elongated, reaching the ground.
Maximum molar ridge-crests: $\frac{3\ 1/2}{4\ 1/2}$.	Maximum ridge-crests: $\frac{5}{5\ 1/4}$.	Maximum ridge-crests: $\frac{4}{4\ 1/2\text{-}5+}$.
Three grinders, M 1 - M 3, in final function.	Two grinders, M 2, M 3, in final function.	One grinder, M^3-M_3, only in final function.
Brachyodont to subhypsodont.	Brachyodont to subhypsodont.	Persistently brachyodont.
Medilongirostral.	Medilongirostral.	Hyperlongirostral.

2. ORDER OF DISCOVERY AND DESCRIPTION OF THIRTY-FOUR SPECIES OF THE SERRIDENTINÆ, FOUR OF THE PLATYBELODONTINÆ, AND TWO OF THE NOTIOMASTODONTINÆ, DURING THE PERIOD 1873–1935

SPECIES OF SERRIDENTINUS.—It has required very prolonged and intensive research to separate the twenty-three species of *Serridentinus* at present known from their original references to other genera as shown in the following table. It is certainly remarkable that the type of *Mastodon obscurus*[1] Leidy, 1869, proves to belong to the genus *Serridentinus*, not only in its fundamental molar structure but in its broad resemblance to many other species more recently discovered on our own eastern and southeastern coast. Quite close to the Miocene *Mastodon obscurus* Leidy of Maryland is the *Serridentinus simplicidens*[1] Osborn, 1923, of the Lower Pliocene of Pierce, Florida. The early geologic arrival of these two primitive species on our southeastern coast is followed by the continuous evolution of a progressive series of species including *Mastodon* [= *Serridentinus*] *floridanus*[2] Leidy, 1886, *S.* [*floridanus*] *leidii*[2] Frick, 1926, *S. brewsterensis* Osborn, 1926, of central Florida, *S. obliquidens*[2] Osborn, 1926, of Charleston, S. C., and of Tarboro, N. C., and finally three new genera (*Ocalientinus*, *Serbelodon* and *Trobelodon*) described by Frick (1933) from the Santa Fé marls in the southwest and the Ainsworth beds of Nebraska (see Sections 8 and 9).

Thus the following table presenting the *chronology of discovery and description* should be studied with the geographic distribution map (Fig. 344), indicating all[3] the localities in which the *types* of the thirty-four species of Serridentinæ and the four species of Platybelodontinæ were found, and compared with the two tables (p. 387) showing in part the supposed evolutionary order of ascent and of diphyletism.

[1]Recently (December, 1932) redetermined as belonging to the genus *Trilophodon*.
[2]Referred (1933) to the genus *Ocalientinus*.
[3]See footnote on page 384.

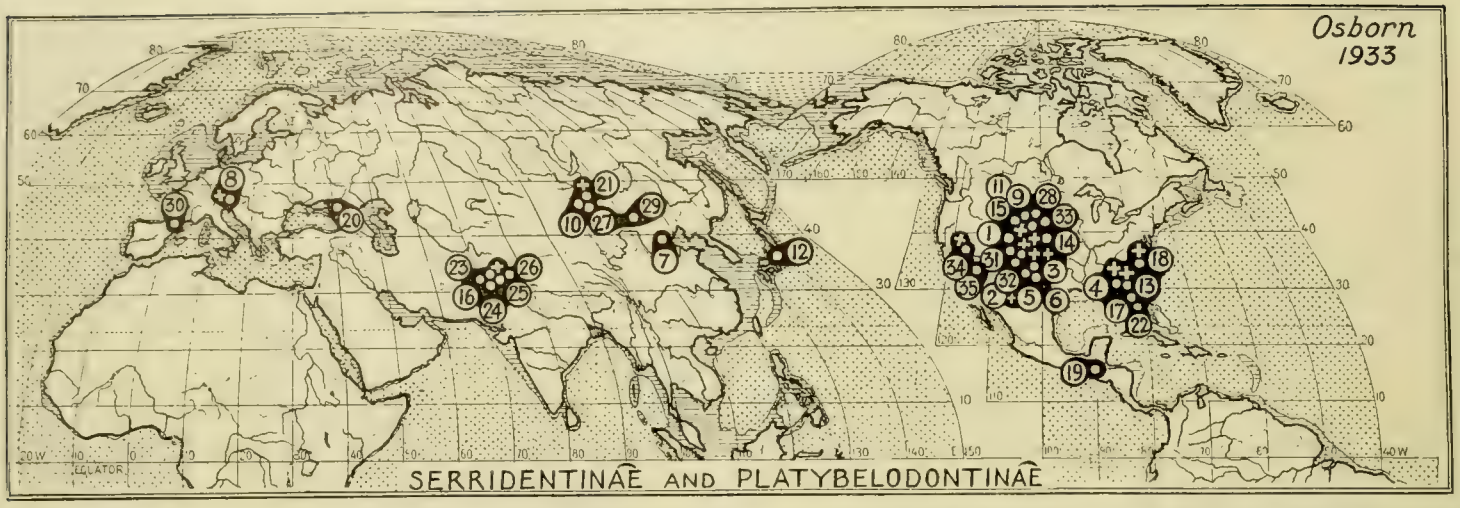


Fig. 344. Geographic distribution of thirty-four[1] species of the Serridentinæ, four species of the Platybelodontinæ, and two species of the Notiomastodontinæ. The white dots within the black areas represent the approximate localities where the types were discovered. The white crosses represent referred specimens mentioned in the present Memoir.

CHRONOLOGIC ORDER OF DISCOVERY AND DESCRIPTION OF THIRTY-FOUR SPECIES OF SERRIDENTINÆ, FOUR OF PLATYBELODONTINÆ, AND TWO OF NOTIOMASTODONTINÆ

See Figure 344

	Geologic Age		Original Name	Specific Reference in Present Memoir
1.	Upper Miocene	1873	*Mastodon proavus* Cope, Pawnee Creek, Colorado	= *Serridentinus proavus*
2.	Upper Miocene	1875	*Mastodon productus* Cope, Santa Fé marls, New Mexico	= *Serridentinus productus*
3.	Lower Pliocene	1884	*Mastodon serridens* Cope, of Clarendon (?) age, Texas	= *Serridentinus serridens*
4.	Lower Pliocene	1886	*Mastodon* (*Trilophodon*) *floridanus* Leidy, Mixson's bone bed, near Williston, Levy County, Florida	= *Ocalientinus* (*Serridentinus*) *floridanus*
4a.	Pliocene	1888	*Mastodon argentinus* Ameghino, Argentina	= *Notiomastodon argentinus*
5.	Upper Pliocene	1892	*D.* [*Dibelodon*] *præcursor* Cope, Mt. Blanco, Llano Estacado, Texas	= *Serbelodon*(?) *præcursor*
6.	Lower Pliocene	1893	*Tetrabelodon serridens cimarronis* Cope, Clarendon of Texas, east of Llano Estacado, Texas	= *Serridentinus serridens cimarronis*
7.	Lower Pliocene(?)	1903	*Mastodon Lydekkeri* Schlosser, Röthliche Sande = Tientsin, Honan, etc., north China	= *Serridentinus lydekkeri*
8.	Lower Middle Miocene	1917	*Mastodon* (*Bunolophodon*) *angustidens* Cuv. f. *subtapiroidea* Schlesinger, Lower Helvetian, Wies, near Eibiswald (Steiermark), Austria	= *Serridentinus subtapiroideus*
	[Lower Pliocene	1923	*Serridentinus simplicidens* Osborn, Pierce, Florida	= *Trilophodon simplicidens* (see Chap. VIII, p. 285, also fig. 231)]
9.	Pliocene (?)	1923	*Trilophodon progressus* Osborn, Driftwood Creek, Hitchcock County, Nebraska	= *Serridentinus progressus*
10.	Lower to Middle Miocene	1924	*Serridentinus mongoliensis* Osborn, Loh, Mongolia	= *Serridentinus mongoliensis*
11.	Lower Pliocene	1924	*Stegomastodon nebrascensis* Osborn, Snake Creek, western Sioux County, Nebraska	= *Serridentinus nebrascensis*
12.	Lower (?) Miocene	1924	*Hemimastodon annectens* Matsumoto, Banjôbora, Kaminogô-mura, Kani District, Province of Mino, Japan	= *Serridentinus annectens*
13.	Lower Pliocene	1926	(?) *T.* [*Trilophodon*] (*S.*) [*Serridentinus*]) *leidii* Frick, Mixson's bone bed, near Williston, Levy County, Florida	= *Ocalientinus* (*Serridentinus*) *floridanus leidii*
14.	Lower Pliocene	1926	*Serridentinus republicanus* Osborn, Republican River formation, northwestern Kansas	= *Ocalientinus* (*Serridentinus*) *republicanus*
15.	Lower Pliocene	1926	*Serridentinus anguirivalis* Osborn, Snake Creek (upper levels), Sioux County, western Nebraska	= *Serridentinus anguirivalis*

[1]No. 4a (*Mastodon* [*Notiomastodon*] *argentinus* Ameghino, 1888), No. 27a (*Torynobelodon loomisi* Barbour, 1929), No. 27b (*Notiomastodon ornatus* Cabrera, 1929), No. 27c (*Gomphotherium*? [*Ocaliuntinus*] *emmonsi* Hay, 1930), and No. 36 (*Trilophodon* [*Serridentinus*] *wimani* Hopwood, 1935) were determined by the present writer too late for insertion on the above map (Fig. 344). See, however, maps (Fig. 189, No. 35, and Fig. 501, Nos. 5 and 28) for plotting of *T. loomisi N. argentinus*, and *N. ornatus*.

16.	Mio-Pliocene	1926	*Serridentinus browni* Osborn, Lower Chinji, Lower Siwaliks, near Chinji Bungalow, India	= *Serridentinus browni*
17.	Lower Pliocene	1926	*Serridentinus brewsterensis* Osborn, Brewster, Florida	= *Serridentinus brewsterensis*
18.	Pliocene, redeposited in Lower Pleistocene	1926	*Serridentinus obliquidens* Osborn, near Charleston, South Carolina	= *Ocalientinus (Serridentinus) obliquidens*
19.	Upper Pliocene	1926	*Serridentinus guatemalensis* Osborn, Chinautla, Guatemala	= *Serridentinus guatemalensis*
	[Miocene	1928	*Trilophodon (Serridentinus?) inopinatus* Borissiak and Beliaeva, Turgai region, Asia	= *Trilophodon inopinatus*, see Chap. VIII]
	[Middle to Upper Miocene	1928	*Serridentinus fricki* Peterson, Douglas Mountain, Weller Ranch, Moffat County, Colorado	= *Trilophodon fricki*, see Chap. VIII]
20.	Upper Miocene	1928	*Platybelodon Danovi* Borissiak, Kuban region, north Caucasus. Chokrak beds	= *Platybelodon danovi*
21.	Upper Miocene	1929	*Amebelodon grangeri* Osborn, Tairum Nor Basin, Mongolia	= *Platybelodon grangeri*
22.	Lower Pliocene	1929	*Serridentinus bifoliatus* Osborn, Brewster, Polk County, Florida	= *Ocalientinus (Serridentinus) bifoliatus*
23.	Middle Pliocene	1929	*Serridentinus hasnotensis* Osborn, near Hasnot, India	= *Serridentinus hasnotensis*
24.	Mio-Pliocene	1929	*Serridentinus metachinjiensis* Osborn, Lower Chinji, Lower Siwaliks, near Chinji Bungalow, India	= *Serridentinus metachinjiensis*
25.	Mio-Pliocene	1929	*Serridentinus chinjiensis* Osborn, Lower Chinji, Lower Siwaliks, near Chinji Bungalow, India	= *Serridentinus chinjiensis*
26.	Mio-Pliocene	1929	*Serridentinus prochinjiensis* Osborn, Lower Chinji, Lower Siwaliks, near Chinji Bungalow, India	= *Serridentinus prochinjiensis*
27.	Pliocene	1929	*Serridentinus florescens* Osborn, Kholobolchi Nor region, Mongolia	= *Ocalientinus (Serridentinus) florescens*
27a.	Middle Pliocene	1929	*Torynobelodon loomisi* Barbour, southwest of Republican City, Harlan County, Nebraska	= *Torynobelodon loomisi*
27b.	Lower(?) Pleistocene	1929	*Notiomastodon ornatus* Cabrera, Monte Hermoso, Province of Buenos Aires, Argentina	= *Notiomastodon ornatus*
27c.	Pliocene	1930	*Gomphotherium*(?) *emmonsi* Hay, marl beds of North Carolina	= *Ocalientinus emmonsi*
28.	Lower Pliocene	1931	*Torynobelodon barnumbrowni* Barbour, Snake River, near Valentine, Cherry County, Nebraska	= *Torynobelodon barnumbrowni*
29.	Upper Miocene	1932	*Serridentinus gobiensis* Osborn and Granger, near Iren Dabasu, Mongolia	= *Serridentinus gobiensis*
30.	?	1933	*Serridentinus filholi* Frick, Gers, France	= *Serridentinus filholi*
31.	Mio-Pliocene	1933	*Ocalientinus ojocaliensis* Frick, Ojo Caliente, New Mexico	= *Ocalientinus ojocaliensis*
32.	Mio-Pliocene	1933	*Trobelodon taoensis* Frick, Santa Cruz, New Mexico	= *Trobelodon taoensis*
33.	Lower Pliocene	1933	*Serbelodon barbourensis* Frick, near Ainsworth, Nebraska	= *Serbelodon barbourensis*
34.	Mio-Pliocene	1933	*Trilophodon barstonis* Frick, Mohave Desert, California	= *Serridentinus barstonis*
35.	Upper Pliocene	1933	*Serbelodon burnhami* Osborn, near Ricardo, California	= *Serbelodon burnhami*
36.	Middle(?) Miocne (Sarmatian)	1935	*Trilophodon wimani* Hopwood, Sining Hsien, Province of Kansu, China	= *Serridentinus wimani*

Geographic Range.—The geographic distribution of the above species is decidedly discontinuous, namely, in India, Mongolia, China, Japan, Austria, France, California, western Nebraska, Kansas, Colorado, New Mexico, Texas, Guatemala, Mexico, Florida, North and South Carolina, and Argentina. In the Lower Miocene lignites of Eibiswald (Styria), Austria, occur the type and referred specimens of *Serridentinus subtapiroideus* which exhibit a grinding tooth structure very similar in form to the primitive grinders of *Trilophodon obscurus* of Maryland.

Companionship with Rhinoceroses. In Mongolia, *Serridentinus mongoliensis* occurs in the same beds with the smaller form of hornless rhinoceros *Baluchitherium mongoliense*. In Pawnee Creek, Colorado, *S. proavus* occurs in the same beds with *Aphelops megalodus* and *Teleoceras medicornutus*. In Kansas, *Ocalientinus (S.) republicanus* occurs in the same beds with *Tetralophodon campester*. In Florida, *O. (S.) floridanus* occurs in the same beds with *Teleoceras proterus*. In New Mexico, *S. productus* occurs in the same beds with the more recent *Trilophodon pojoaquensis*. In the upper Snake Creek beds of western Nebraska, *Serridentinus anguirivalis* occurs in the same beds with other proboscideans such as *S. nebrascensis*, *Pliomastodon matthewi*, and *Rhynchotherium anguirivalis*.

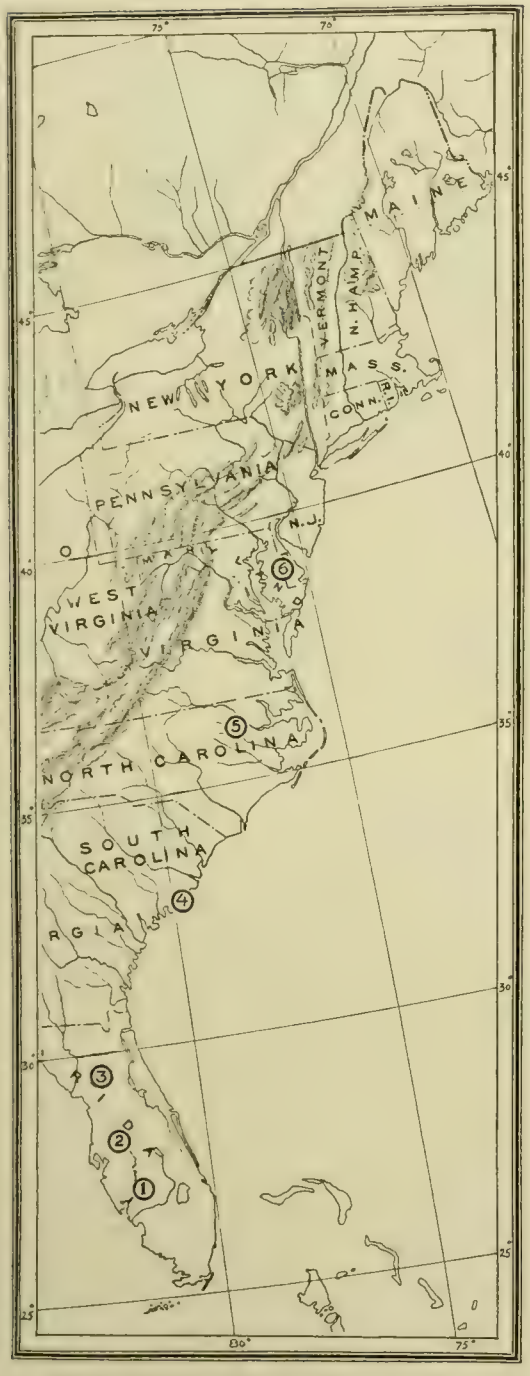


Fig. 345. Proboscidean localities of eastern coast of United States. Compare Osborn, 1910.346, fig. 171.

6. Miocene of Maryland, Choptank formation. *Trilophodon obscurus* type.

5. Pliocene of North Carolina, Tarboro. *Ocalientinus* (*Ser.*) *obliquidens* ref.

4. Pliocene redeposited in Pleistocene phosphate beds of South Carolina, Charleston. *Ocal.* (*Ser.*) *obliquidens* type.

3. Pliocene of Florida, Alachua clays, Mixson's bone bed, near Williston. *Ocal.* (*Ser.*) *floridanus* type.

2. Pliocene of Florida, Bone Valley formation, pebble phosphate beds, Brewster, Pierce. Types of *Trilophodon simplicidens*, *Serridentinus brewsterensis*, *Ocal.* (*Ser.*) *bifoliatus*.

1. Pleistocene, Peace Creek, Florida.

Geologic Range.—The known geologic range of *Serridentinus* accompanied by these various rhinoceroses appears to be from the Middle Miocene to the Upper Pliocene, from Mongolia to central Florida. From this friendly association of various species of *Serridentinus* with various species of rhinoceroses, *Baluchitherium*, *Aphelops*, *Teleoceras*, we infer that *Serridentinus* enjoyed similar local habitats, similar food regions, and similar temperature zones to those of the rhinoceroses and mastodonts above mentioned. It is probable that *Serridentinus* and the rhinoceroses flourished during the same geologic periods, but the rhinoceroses disappeared from America during Upper Pliocene time, also *Serridentinus*, i. e., *Ocalientinus* (*Ser.*) *obliquidens*, which thus far has not been discovered in Pleistocene time (Simpson, 1930, p. 208).

Diphyletic Succession of Species.—We have observed in Chapter VIII that all the ascending species of *Trilophodon* appear to belong in two phyla: (A) With slender jaws, (B) with massive jaws (p. 331, also see Figs. 188 and 282).

The species of Serridentinæ appear to belong in two ascending phyla: (A) With roundly blunted cones and conelets which never form completely sharpened crests but terminate in rounded cones, and (B) with sharply pointed crests and smaller serrations of the trefoil spurs. It appears that these two Serridentine phyla evolved independently and gradually became adapted to different local habitats: (A) To a moister climate and the more succulent food of the eastern coast (Figs. 345, 359); (B) to a dryer climate and the more resistant food of the western plateaus.

The separation of the above phyla (A) and (B), in the case of certain species, is not very sharply indicated, consequently the

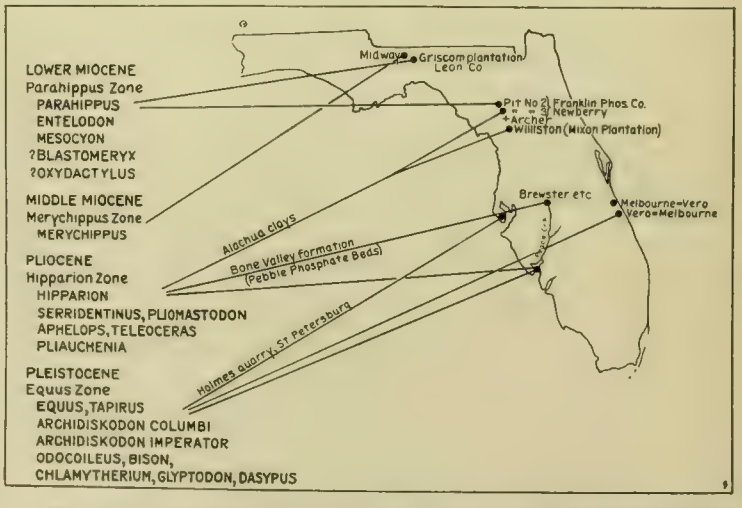


Fig. 346. Serridentines of the Florida Pliocene and contemporary *Hipparion*, *Pliomastodon*, rhinoceroses, and camels. Diagram by Matthew, May, 1926.

diphyletic division into (A) and (B) is to be regarded as more or less provisional until more complete material is discovered.

The *phylogenetic or ascending order of evolution* of the thirty-four species is, however, perfectly clear; it is indicated in (1) the size of the third grinding teeth, (2) the number of ridge-crests, and (3) the elevation of the ridge-crests. The phylogenetic order, therefore, is followed below in the order of systematic descripton of the species of Serridentinæ, with the exception of those of the Siwaliks (see Section 10 of the present Chapter).

According to the partly theoretic division referred to above, the diphyletic grouping into (A) and (B) of the species of Serridentinæ known at the present time is as follows:

Two Ascending Phyla of Serridentinæ in Provisional Order

(A) With roundly blunted cones and conelets, not forming sharpened or elevated crests. Ridge-crests with double internal (ento-), external (ecto-) crests or spurs.

Third superior molars subquadrate in form, slightly contracting posteriorly.

Ocal. (Ser.) obliquidens, Pliocene, near Charleston, S. C. Crests strongly inclined forwards. M_3, ap. 193e mm., tr. 83e mm.; with ? 5¼ ridge-crests.

Serridentinus hasnotensis, Middle Pliocene, near Hasnot, India. Crests massive, vertical. M^3, ap. 190e mm., tr. 94 mm.; with 4⅓ ridge-crests.

Ocal. (Ser.) floridanus, Alachua clays, Pliocene, near Williston, Florida. Crests somewhat inclined. M_3, ap. 226 mm., tr. 85 mm.; with 5¼ ridge-crests.

Ocal. (Ser.) bifoliatus, Pliocene, Brewster, Florida. M_3, ap. 195 mm., tr. 81 mm.; with 5 ridge-crests.

Ocal. (Ser.) republicanus, Republican River, Kansas. M_3, ap. 210 mm., tr. 70 mm.; with 4¾ ridge-crests. Pliocene.

Serridentinus nebrascensis, Lower Pliocene, Snake Creek, Sioux County, Nebraska. M^1, ap. 83 mm., tr. 59 mm., with 3 ridge-crests.

Serridentinus browni, Mio-Pliocene, near Chinji Bungalow, India. M_3, ap. 170e mm., tr. 80 mm.; with 4¼ ridge-crests.

Serridentinus metachinjiensis, Mio-Pliocene, near Chinji Bungalow, India. Crests subhypsodont, no cement. M_3, ap. 214 mm., tr. 85 mm.; with 4½ ridge-crests.

Serridentinus proavus, Pawnee Creek, Colorado. P^4, ap. 52 mm., tr. 47 mm.; with 2 ridge-crests. Upper Miocene.

Serridentinus productus, Santa Fé marls, New Mexico. M_3, ap. 164 mm., tr. 74 mm.; 4⅓ ridge-crests. Upper Miocene.

Serridentinus mongoliensis, Loh, Mongolia. M_3, ap. 138 mm., tr. 63 mm.; with 3¾ ridge-crests. Lower to Middle Miocene.

Serridentinus prochinjiensis, Mio-Pliocene, near Chinji Bungalow, India. M_2, ap. 105e mm., tr. 58 mm.

Serridentinus subtapiroideus, Eibiswald (Styria), Austria. M^3, ap. 150 mm., tr. 83 mm.; with 4⅓ ridge-crests. Miocene.

Ocal. (Ser.) florescens, Kholobolchi Nor region, Mongolia. M_2, ap. 131e mm., tr. 45+ mm.; with 3 ridge-crests. Pliocene.

Serridentinus gobiensis, Iren Dabasu, Mongolia. M_3, ap. 195 mm., tr. 87 mm.; with 4⅓ ridge-crests. Upper Miocene.

(B) With ridge-crests progressively elevated and sharpened, and finely serrated trefoil spurs. Ridge-crests with treble or quadruple internal (ento-), external (ecto-) crests or spurs.

Third superior molars subtriangular in form, rapidly contracting posteriorly.

Serridentinus guatemalensis, Upper Pliocene, Chinautla, Guatemala. M^3, ap. 170e mm., tr. 83 mm., with 4¼ ridge-crests.

(?)*Serridentinus*[1] *præcursor*, Upper Pliocene, Mt. Blanco, Texas. M^3, ap. 155e mm., tr. 70 mm.; with 4½ ridge-crests.

Serridentinus brewsterensis, Lower Pliocene, Brewster, Florida. M^3, ap. 179 mm., tr. 87 mm.; with 3¾–4 ridge-crests.

Serridentinus chinjiensis, Mio-Pliocene, near Chinji Bungalow, India. M^3, ap. 160e mm., tr. 91 mm.; with 4 ridge-crests plus cingulum.

Serridentinus serridens cimarronis, Lower Pliocene, Clarendon of Texas. M^3, ap. 140 mm., tr. 80 mm.; with 3½ ridge-crests.

Serridentinus anguirivalis, Pliocene, Snake Creek, Nebraska. M^3, ap. 145e mm., tr. 81e mm.; with 4 ridge-crests.

Serridentinus serridens, Lower Pliocene, Texas. M^3 with 4⅓ est. ridge-crests. M^2, ap. 130 mm., tr. 80 mm.

Adaptations (A).—The relatively low, blunt grinding teeth in all the above species (A) were apparently adapted to the more succulent vegetation of the well-watered lowlands of Florida and of the Atlantic States north to Maryland.

Adaptations (B).—The sharpened grinding teeth in the above species (B) were apparently adapted to the less succulent vegetation of the more arid plateaus and uplands of the Pliocene of Texas and Mexico. The only exceptions are the species *Serridentinus brewsterensis*, which occurs in Florida, and *S. chinjiensis* occurring in India.

Frick Collection, 1933[2]

Ocalientinus ojocaliensis, Mio-Pliocene, Ojo Caliente, New Mexico. M^3, ap. 177 mm., tr. 85 mm., with 4½ ridge-crests; M_3, ap. 191e mm., tr. 75e mm., with 4½ ridge-crests.

Serbelodon barbourensis, Lower Pliocene, near Ainsworth, Nebraska, M^3, ap. 141 mm , tr. 88 mm., with 4½ ridge-crests; M_3, 170 mm., tr. 77 mm., with 4½ ridge-crests.

Serbelodon burnhami, Upper Pliocene, near Ricardo, California.

[1]Doubtfully referred (1935) to the genus *Serbelodon*.

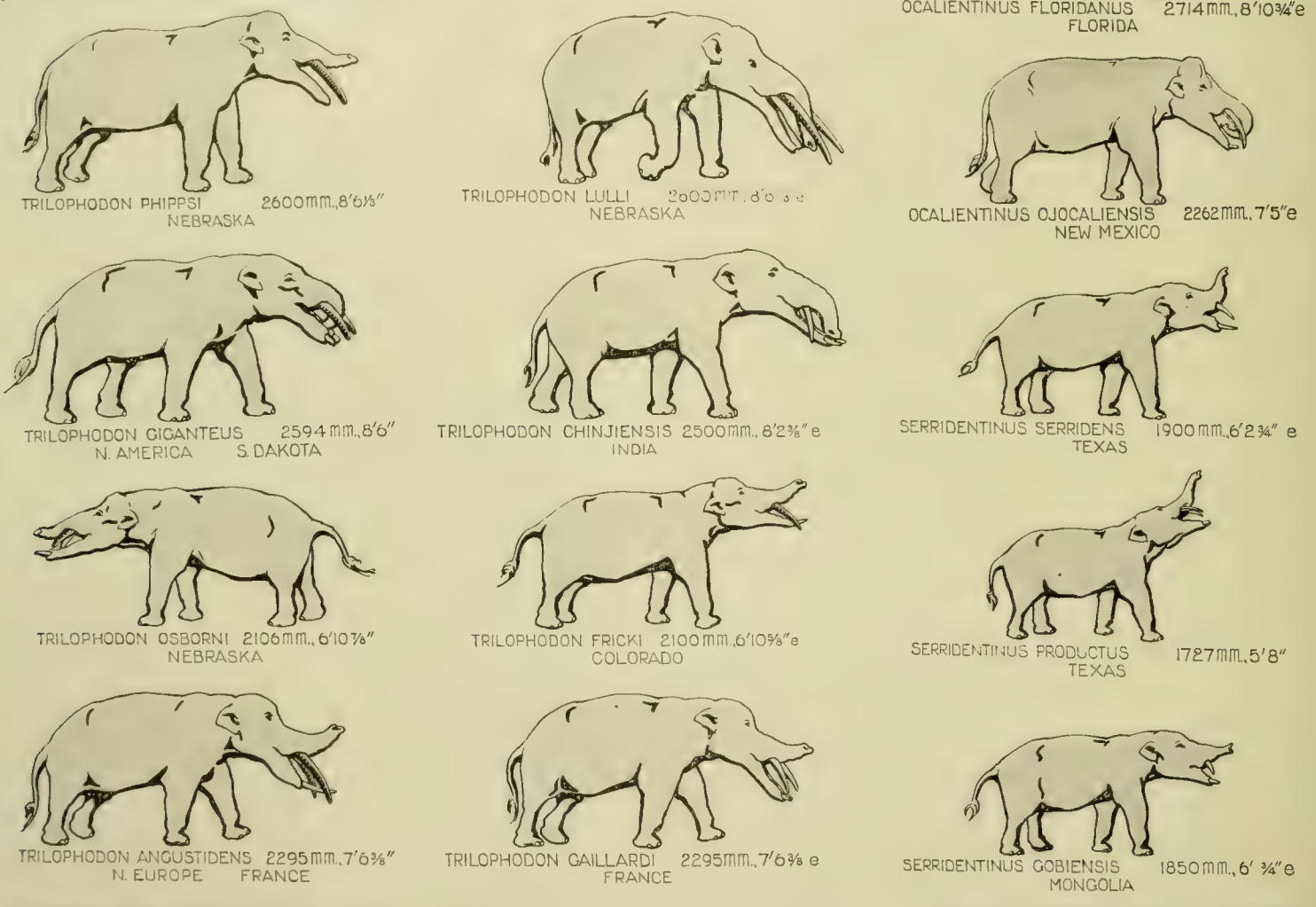
[2]To the above three species the Frick Collection has added *Trobelodon taoensis* from Santa Cruz, New Mexico, and *Trilophodon* [*Serridentinus*] *barstonis* from the Mohave Desert, California.

Contrast between Hyperlongirostral Species of Trilophodon (Left) and Medilongirostral Species of Serridentinus and Ocalientinus (Right). Compare Figure 234

Restorations by Margret Flinsch, under the direction of Henry Fairfield Osborn

Uniform scale of one-hundredth natural size, as restored in 1932–1933

Fig. 347. The relatively small body size, abbreviate jaws, and low stature of five species of the forest-loving *Serridentinus* and *Ocalientinus* are to be compared with the larger stature and longer jaws and tusks of eight species of *Trilophodon*.



Trilophodon phippsi. Restored from complete skeleton in Denver Museum; mandible lacking inferior tusks. Height 2600 mm.

Trilophodon giganteus. Restored from nearly complete skeleton in American Museum (Amer. Mus. 17359). Height 2594 mm.

Trilophodon osborni. Restored from complete cranium and partial skeleton in the Nebraska Museum. Height 2106 mm.

Trilophodon angustidens. Restored from cranium and jaws in the Paris Museum. Height 2295 mm.

Trilophodon lulli. Restored from the type upper tusks and lower jaw in the Nebraska Museum. Height 2600 mm.

Trilophodon chinjiensis. Restored from complete mandible in the American Museum (Amer. Mus. 19421). Height 2500 mm.

Trilophodon fricki. Restored from type jaw in the Carnegie Museum. Height 2100 mm.

Trilophodon gaillardi. Restored from type jaw in the Lyons Museum (cast Amer. Mus. 21904). Height 2295 mm.

Ocalientinus floridanus. Restored from superior and inferior grinding teeth in the U. S. National Museum. Height 2714 mm.

Ocalientinus ojocaliensis. Restored from superb skull and jaws together with skeletal parts in the American Museum (F:A.M. 21294). Height 2262 mm.

Serridentinus serridens. Restored from complete cranium in the American Museum (Amer. Mus. 10673). Height 1900 mm.

Serridentinus productus. Restored from complete cranium and partial skeleton in the American Museum (Amer. Mus. 10582). Height 1727 mm.

Serridentinus gobiensis. Restored from lower jaw and dentition in the American Museum (Amer. Mus. 26461). Height 1850 mm.

3. SYNOPSIS OF SUBFAMILY, OF GENERIC, AND OF SPECIFIC CHARACTERS. ASCENDING PHYLOGENETIC ORDER OF THE SPECIES

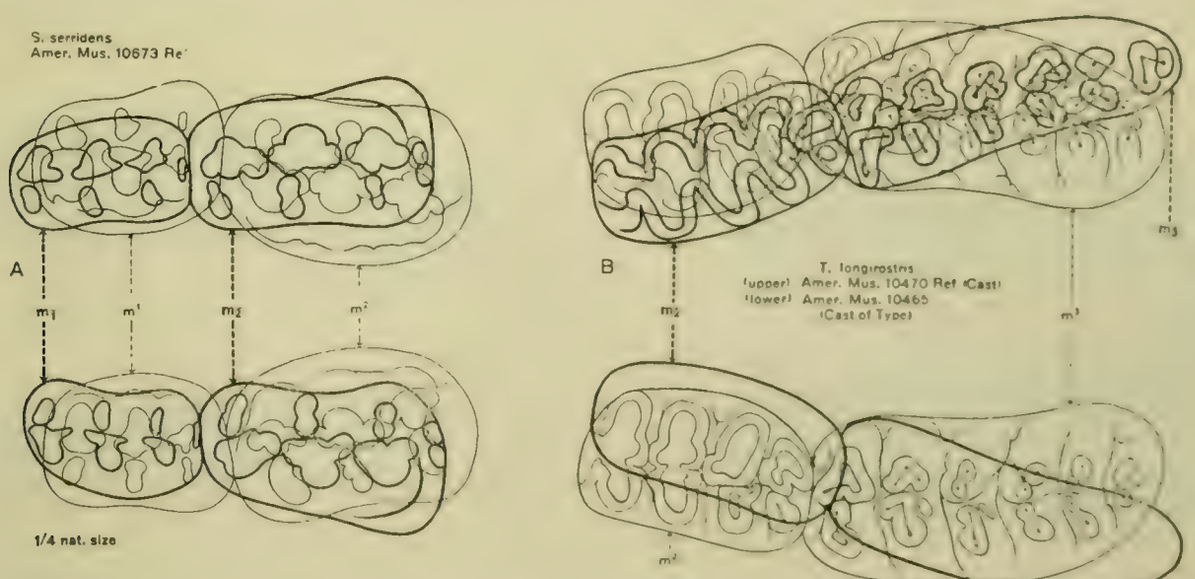
SUPERFAMILY: MASTODONTOIDEA Osborn, 1921

FAMILY: SERRIDENTIDÆ Fam. nov.

SUBFAMILY: SERRIDENTINAE Osborn, 1921

Original reference: Osborn, Bull. Geol. Soc. Amer., 1921, Vol. XXXII, p. 330 (Osborn, 1921.526).

SUBFAMILY CHARACTERS.—(1) The Serridentinæ of Osborn are based on the genus *Serridentinus* Osborn, 1923. (2) The jaws are medilongirostral. (3) The 'intermediate molars' are trilophodont from the beginning to the end of the phylum *Serridentinus* as well as from the beginning to the end of the phylum *Trilophodon*. (4) The grinding teeth are relatively *broader* than in *Trilophodon;* (5) the trefoil crests or spurs arise on the *inner* conelets of the superior, and on the *outer* conelets of the inferior molar ridge-crests; (6) median conules never arise in the center of the valleys, as in *Trilophodon;* (7) the prevailing *ridge formula* is practically the same in *Serridentinus* as in *Trilophodon*, namely, Dp 4; M 1; M $2\frac{3}{3}$ M $3\frac{5}{5\ 1/4}$. (8) The superior incisive tusks persistently curve downwards and outwards and retain a broad functional enamel band. (9) The inferior incisive tusks are without enamel, broadly flattened, closely appressed, and are never greatly elongated as in *Trilophodon*. (10) Functional retention and usage of the second and third molar teeth, M 2, M 3, in both upper and lower jaws, in contrast to the Longirostrinæ (*Trilophodon*) and Tetralophodontinæ (*Tetralophodon*), in which mastication is finally concentrated on the upper and lower posterior molars, M 3.



SERRIDENTINUS (LEFT) AND TETRALOPHODON (RIGHT) GRINDING TEETH SUPERPOSED. COMPARE FIGURES 308, 329, 349, AND 350

Fig. 348. Heavy lines indicate lower grinders; light lines indicate upper grinders.

A, *Serridentinus serridens*. Observe *external* trefoils of *lower* molars (=heavy lines); *internal* trefoils of *upper* molars (=light lines).

B, *Tetralophodon longirostris*. Observe central trefoils, single or double, of lower molars (=heavy lines), double trefoils (central) of upper molars (=light lines).

Comparison of M^2-M_2 in A and B clearly illustrates the profound difference between the grinding teeth in the Serridentinæ (A) and the Tetralophodontinæ (B).

The known Serridentinæ now (1935) embrace thirty-four species which are subdivided into two phyletic series adapted respectively to moister and to dryer climatic conditions, as shown in (A) and (B) on page 387.

The above ten subfamily characters should be compared with those of the subfamily Longirostrinæ enumerated on page 231[1]. The Longirostrinæ consist of one generic phylum, namely, *Trilophodon* (including *Choerolophodon*); the Tetralophodontinæ of one, namely, *Tetralophodon* (including *Lydekkeria* and *Morrillia*); the subfamily Serridentinæ branch into four generic phyla, in which the more recent species are distinguished from those geologically more ancient chiefly by progressive characters such as (a) reduplication of the conelets on the

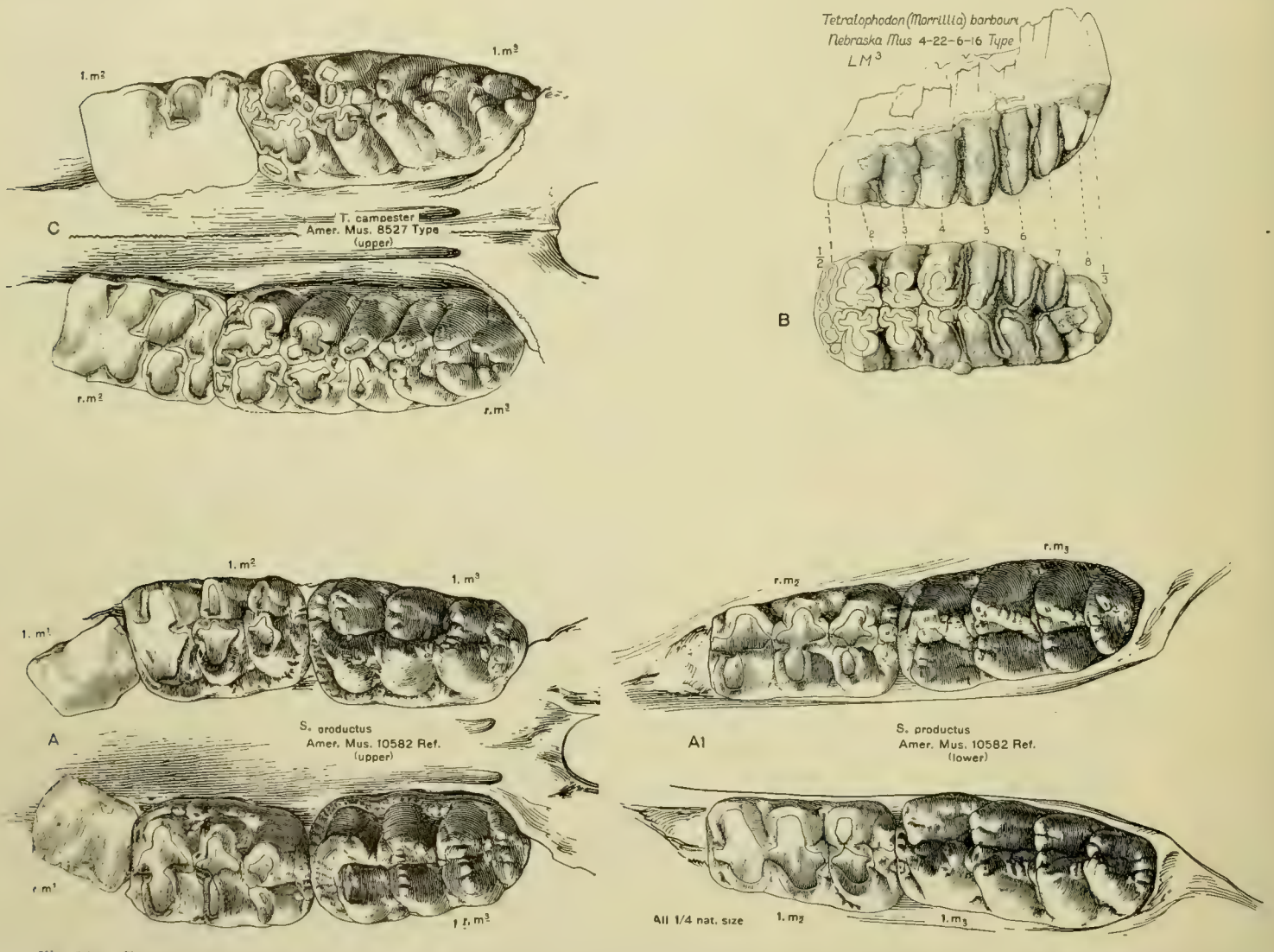


Fig. 349. Contrast of adult second and third superior and inferior molars in *Tetralophodon* (C) and *Serridentinus* (A, A1), third molars in place; also in *Morrillia* (B). All one-fourth natural size.

GENUS: *Tetralophodon* B, *Tetralophodon* (*Morrillia*) *barbouri* type; left M^3, with $8\frac{1}{3}$ crests, double trefoils, cement. Side and crown views.

C, *Tetralophodon campester* type; M^3 with 5 full and 2 half crests, no cement.

GENUS: *Serridentinus* A, *Serridentinus productus* referred superior molars, M^{1-3}; $3\frac{1}{3}$ crests in M^3.

A1, *Serridentinus productus* referred second and third inferior molars; $4\frac{1}{3}$ crests in M_3.

A and A1, Dentition of adult skull (Amer. Mus. 10582), compare figures 369 and 370.

[1]Also with the generic characters of *Ocalientinus*, *Serbelodon*, and *Trobelodon* of Frick (see Sections 8 and 9).

sides of the crests, (b) progressive elevation of the ridge-crests from the purely brachyodont condition (e.g., *Serridentinus mongoliensis*) to the elevated condition (e.g., *Ocal.* (*Ser.*) *floridanus*), and (c) progressive addition of ridge-crests (e.g., M 3, ridge-crests 3¾, 4½, 5¼).

Consequently it appears at present that the Serridentinæ are *polyphyletic*, in contrast to the *monophyletic* Longirostrinæ.

LONGIROSTRINÆ: TREFOILS CENTRAL; SUPERIOR INCISIVE TUSKS ROUNDED, PROGRESSIVELY HORIZONTAL AND ELONGATED; INFERIOR TUSKS PROGRESSIVELY ELONGATED (COMPARE FIGS. 172, 188).

HYPERLONGIROSTRAL

Trilophodon. Typified by *Trilophodon angustidens;* jaws extremely elongate and slender, increasing in length in ascending species; third superior molars and especially third inferior molars narrowing to an index of 39 in *T. angustidens;* conules arising in the center of the molar crowns; trefoils from the center of the external cones in the lower molars, from the center of the internal cones in the upper molars.

This phylum embraces all the Hyperlongirostrines, for example: Typical *Trilophodon angustidens*, Simorre, Sansan; *T.* (*Genomastodon*) *osborni*, Nebraska, *T. giganteus*, South Dakota.

MEDILONGIROSTRAL

Tetralophodon. Typified by *Tetralophodon longirostris;* jaws of medium length; intermediate molars with four ridge-crests, posterior molars with ridge-crests increasing from five and a half to eight and a third (*Morrillia*).

SERRIDENTINÆ: TREFOILS LATERAL; SUPERIOR INCISIVE TUSKS LATERALLY COMPRESSED, DOWNCURVED AND OUTCURVED; INFERIOR TUSKS FLATTENED, LESS ELONGATED (COMPARE FIGS. 350, 366, 370).

MEDILONGIROSTRAL

Serridentinus. Typified by *Serridentinus serridens,* etc.; jaws moderately elongate, relatively stout, less rapidly increasing in length, tending to decurvature; third inferior molars relatively broader with an index of 47 in *S. productus;* trefoils arising from the outer side of the external cones in the lower molars, from the inner side of the internal cones in the upper molars.

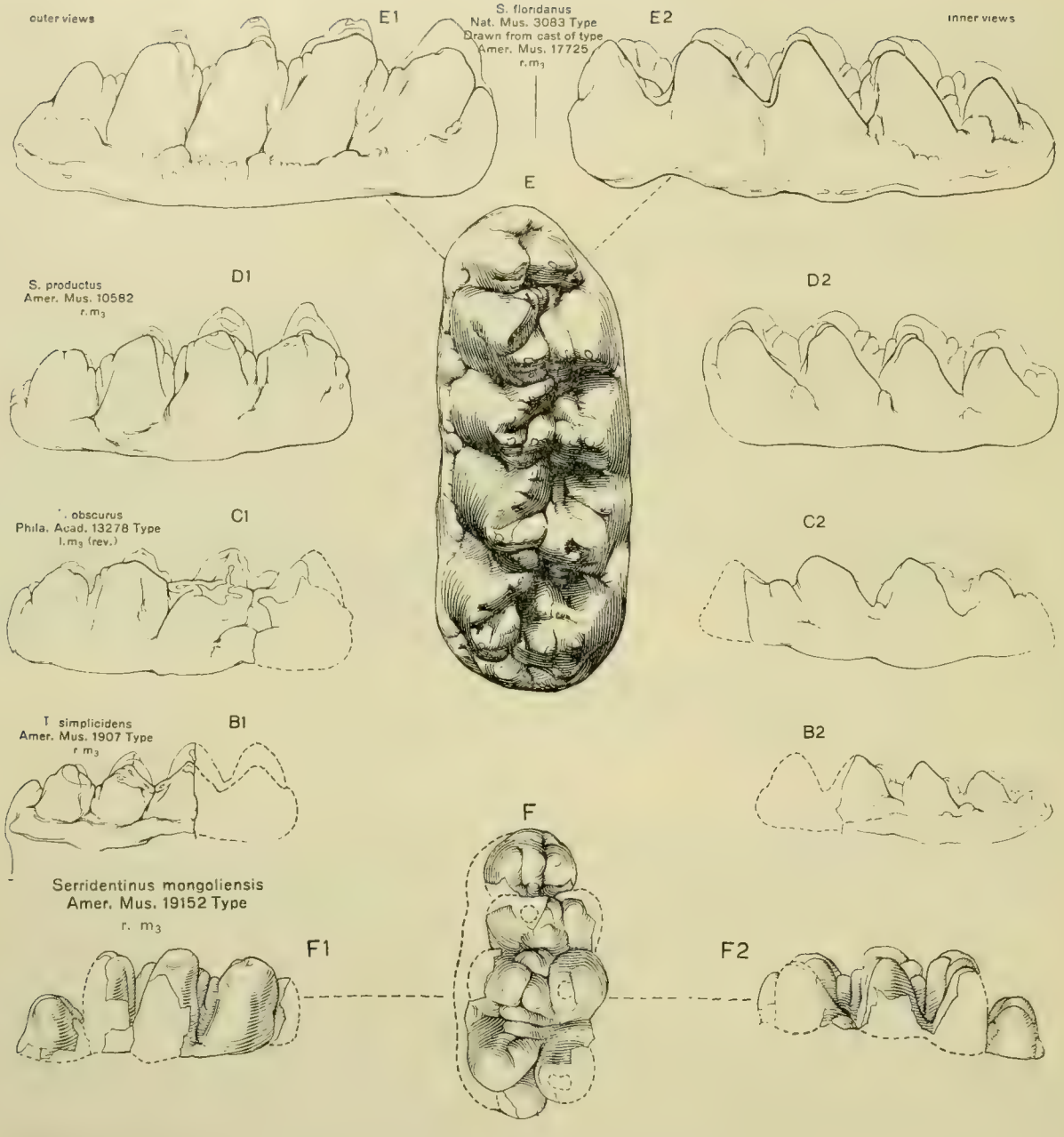
This medilongirostral phylum is represented chiefly by the following: The genotypic species *Serridentinus serridens* of the Lower Pliocene of Texas, *S. productus* of the Upper Miocene of New Mexico, *Ocal.* (*Ser.*) *floridanus* of the Lower Pliocene of Florida, also by Siwalik species described below, and other forms distinguished in the present Memoir, up to 1935.

Recently discovered medilongirostral serridentine mastodonts are: *Ocalientinus ojocaliensis, Serbelodon barbourensis,* and *S. burnhami.*

DENTAL PROPORTIONS IN SERRIDENTINUS

CROWNS OF GRINDERS (Fig. 349).—The contrast between the crowded and medianly placed conules and trefoils of *Tetralophodon campester* (C), of *T.* (*Morrillia*) *barbouri* (B), and the internal-external crests or spurs of *Serridentinus productus* (A, A1) is very clearly shown in the accompanying carefully prepared figure. In the highly progressive species of *Tetralophodon, T. campester* (C) and *T.* (*Morrillia*) *barbouri* (B), double internal and external trefoils arise in addition to the central conules; the crushing crown thereby assumes a chærodont, plicated, or ptychoid structure adapted to grinding action. On the other hand, the cutting crown of *S. productus* (A, A1) elaborates the crests or spurs as in *Ocalientinus* (*Ser.*) *florescens*, but there are never more than single trefoils on the inner and outer sides respectively; the transverse crests, therefore, retain the cutting or chopping function.

BREADTH OF GRINDERS (FIG. 350). We observe that in *Serridentinus* (1) the superior and inferior grinding teeth, Dp 4-M 3, are relatively much broader than in either *Trilophodon* or *Tetralophodon.* (2) The indices of the third superior and inferior molars of *Serridentinus*, especially of M^3 (index 60) and M_3 (index 47), are much broader than in the typical *Trilophodon* in which M^3 = index 51 and M_3 = index 39. (3) When we compare these third superior and inferior molars in *Serridentinus productus* and in *S. progressus* with those of the true *Tetralophodon campester,* as beautifully drawn in the accompanying figures 343, 349, 350, and 331, we also observe a very marked difference in the relatively arrested development of M^3-M_3 in *Serridentinus.*



SERRIDENTINUS (D1, D2, F–F2) AND OCALIENTINUS (E–E2) INFERIOR GRINDERS SERRATED. TREFOILS FROM ECTOCONELETS ONLY. COMPARATIVE SERIES B1, B2, C1, C2 (TRILOPHODON)

ONE-THIRD NATURAL SIZE

Fig. 350. Observe especially: (1) Progressive increase in size; (2) addition of a pentalophid; (3) serration or denticulation of ectolophid crests or spurs; (4) external views to the *left;* (5) internal views to the *right.* Superior *Serridentinus* grinders are shown in other diagrammatic figures, e.g., figure 349 A, A1.

Drawn to the same scale and placed in the same position for direct comparison are the Mongolian and American specimens of *Serridentinus* of the third inferior molar teeth, M_3. To the left the external views showing the serrated ectolophid; to the right the internal views; in the center (F) the least progressive, (E) the most progressive members of the series.

E, E1, E2, *Ocalientinus* (*Ser.*) *floridanus* type, Lower Pliocene of Florida.

D1, D2, *Serridentinus productus* ref., Lower Pliocene of Texas.

C1, C2, *Trilophodon obscurus* type, Miocene of Maryland.

B1, B2, *Trilophodon simplicidens* type, Lower Pliocene of Florida.

F, F1, F2, *Serridentinus mongoliensis* type, Miocene of Mongolia.

Genus: **SERRIDENTINUS** Osborn, 1923

Original reference: Osborn, Amer. Mus. Novitates, No. 99, p. 2 (Osborn, 1923.601).

Genotypic species (cf. Osborn, 1923.601, p. 2): Based upon the genotypic species *Mastodon productus* Cope, *M. serridens* Cope, *M. floridanus* Leidy, . . . below, characteristic of the southeast coast of the United States, abundant in Florida; clearly distinguished from *Trilophodon* by the serrate crests ascending on the outer cones of the lower molars and on the inner cones of the upper molars; true trefoils, i.e., intermediate conules in the center of the valleys, observed in all species of *Trilophodon*, are wanting.

Generic Characters. (1) Ridge-crests progressively increasing in number from three and three-quarters (*Serridentinus mongoliensis*) to four and a fifth (*S. productus*), to five and a quarter (*Ocalientinus* (*Ser.*) *floridanus*).

Primitive ridge formula: ?Dp $4\frac{3}{3}$?P $4\frac{2+}{2+}$ M $1\frac{3}{3}$ M $2\frac{3}{3}$ M 3 $\frac{3\frac{1}{4}\text{ progressive to }5}{3\ 3/4\text{ progressive to }5\ 1/4}$

(2) Primitive Miocene molars brachyodont with more or less prominent lateral crests or trefoil spurs on the internal cones of the superior molars and on the external cones of the inferior molars. (3) Three superior and inferior grinding teeth (M 1 M 3) in use at the same time. (4) Cones gradually elevating from the extremely brachyodont (*S. subtapiroideus*) to the more elevated, subhypsodont (*Ocal.* (*S.*) *floridanus, Ocal.* (*S.*) *republicanus*) stage. (5) Serrations or conelets of trefoil spurs progressively more prominent with tendency to reduplicate (*Ocal.* (*Ser.*) *floridanus, Ocal.* (*S.*) *florescens*).

Geologic, Geographic, and Progressive Range. — (1) This previously unrecognized genus first appears in the geologically very primitive *Serridentinus mongoliensis* discovered to the north of the eastern Altai in Mongolia, apparently of Lower to Middle Miocene age; the third inferior molar, M_3, is characterized by only three main crests and a low fourth crest (Fig. 350 F, F1, F2). (2) A primitive succeeding (Upper Miocene) stage, though geographically remote, is *Serridentinus productus* of the Santa Fé marls of New Mexico (Fig. 350 D1, D2), in which M_3 exhibits four somewhat more elevated crests and a more distinctly serrated condition of the trefoil spurs. (3) The accompanying diagram illustrating the progressive structure of the third inferior molar is arranged in ascending order of size also in the apparent ascending order of the progressive characters of the third inferior molar teeth, viewed in the internal aspect (Fig. 350 F2–E2), in the external aspect (F1-E1). *Trilophodon simplicidens* (B1, B2) and *Trilophodon obscurus* (C1, C2) were included in this figure as they were considered at the time as referable to the genus *Serridentinus*.

One of the genotypic species of this genus is *Mastodon* [= *Serridentinus*] *serridens* Cope from the Pliocene of Texas. This specific stage (see Fig. 342) is much more progressive than that of any of the Miocene species shown in the table below giving the *ascending phylogenetic order*. Yet in all the following twenty species now referred to this genus, the above generic characters may be observed in different degrees of evolution.

Provisional Ascending Phylogenetic Order of the Species of Serridentinus[1]

(A) Blunt ridge-crests

Pliocene
- *Serridentinus obliquidens*[2]
- *Serridentinus hasnotensis*
- *Serridentinus floridanus*[2]
- *Serridentinus bifoliatus*[2]
- *Serridentinus republicanus*[2]
- *Serridentinus lydekkeri*
- *Serridentinus florescens*[2]
- *Serridentinus nebrascensis*
- *Serridentinus progressus*

Miocene
- *Serridentinus gobiensis*
- *Serridentinus mongoliensis*
- *Serridentinus annectens*

Mio-Pliocene
- *Serridentinus browni*
- *Serridentinus metachinjiensis*
- *Serridentinus prochinjiensis*

Miocene
- *Serridentinus subtapiroideus*
- *Serridentinus*(?) *filholi*
- *Serridentinus productus*
- *Serridentinus proavus*

(B) Sharp ridge-crests

Pliocene
- *Serridentinus guatemalensis*
- (?)*Serridentinus præcursor*[3]
- *Serridentinus brewsterensis*
- *Serridentinus serridens cimarronis*
- *Serridentinus anguirivalis*
- *Serridentinus serridens*

Mio-Pliocene
- *Serridentinus chinjiensis*

[1] As to blunt- and sharp-crested Serridentine phyla, compare also Appendix.
[2] Now referred to the genus *Ocalientinus* Frick, 1933.
[3] Now (1935) doubtfully referred to *Serbelodon*.

The above arrangement of the species in ascending phylogenetic order is preliminary to a fuller knowledge of their real characters. In addition to the thirty-four species listed above (p. 384), it seemed possible that the *Mastodon angustidens* var. *libyca* of Fourtau, North Africa, might belong to this Serridentine phylum, since the third inferior molar, M_3, lacks the excessively long, narrow character of *Trilophodon* and resembles *Serridentinus* in proportion. Finally it has been placed in the subfamily Longirostrinæ (see Chapter VIII, p. 260).

Progressive Hypsodonty.—The height of the tritolophid or of the tetartolophid in M_3 may be used as a means of determining the hypsodonty in the following specimens:

O. (*S.*) *floridanus*,	Leidy's type, r.M_3, of *Mastodon floridanus* (cast Amer. Mus. 17725), height of tetartolophid	80 mm.
S. productus,	Cope's type, r.M_3, of *Mastodon productus* (Nat. Mus. 2346), height of tetartolophid	42
S. proavus,	Cope's type of *Mastodon proavus* (Amer. Mus. Cope Coll. 8523), height of (?)tritoloph of r.M^1	52e
T. obscurus,	Leidy's type, l.M_3, of *Mastodon obscurus* (Phil. Acad. 13278), height of tetartolophid	52
T. simplicidens,	Osborn's type, r.M_3, of *Serridentinus simplicidens* (Amer. Mus. 1907), height of tetartolophid	35

I. Ascending Phylum (A). Blunt Ridge-crests

Ascending phylum (A) of serridentinus, including all species with roundly blunted cones and conelets, not forming sharpened or elevated crests. Ridge-crests with double internal (ento-), external (ecto-) conelets. Trefoil spurs with single, double, or treble conelets. The relatively low, blunt grinding teeth in all the species described below were apparently adapted to the more succulent vegetation of the well-watered lowlands of Florida and of the South Atlantic states

4. EURASIATIC SPECIES

Serridentinus subtapiroideus Schlesinger, 1917

Figures 351 B1, B2(?), 352, 353

Wies, near Eibiswald (Styria), Austria. Lower Middle Miocene, age of Sansan.

This Middle Miocene forest-living species (Figs. 351–353), of the lignites of Eibiswald, proves to belong in the genus *Serridentinus* and represents a stage of evolution more progressive than *Trilophodon obscurus* of Maryland and close to *S. productus* of the Upper Miocene of New Mexico and the Lower Pliocene of Texas. The third superior molar of *S. subtapiroideus* (Fig. 352) is more progressive than that of *S. productus* (Fig. 370), because it is composed of *four plus* ridge-crests.

Specific Characters of Serridentinus subtapiroideus (Figs. 352, 351 B1).—Trefoil spurs with single conelets arising from the inner cones in the superior molars, from the outer cones in the inferior molars, inner and outer cones partly separated by a longitudinal fissure. Summits of inferior cones surmounted by two to three conelets, summits of superior cones surmounted by three conelets; subzygodont aspect of the lophs; superior and inferior molars relatively broad and short as compared with the typical *Trilophodon angustidens;* M^2, ap. 112 mm., tr. 72 mm., index 64; M^3, ap. 150 mm., tr. 83 mm., index 55; M^3 elongated subtriangle, narrowing posteriorly (unlike *Trilophodon*), four plus ridge-crests, height of external cone of protoloph 45e mm.

Mastodon (*Bunolophodon*) *angustidens* Cuv. f. *subtapiroidea* n. f. Schlesinger, 1917. "Die Mastodonten des K. K. Naturhistorischen Hofmuseums." Denks. K. K. Naturhist. Hofmuseums, Band I, 1917, pp. 30, 31, 35, 37. Cotypes.—A juvenile maxilla (Taf. III, fig. 2, and Taf. IV, fig. 1) and an adult maxilla containing r.M^{2-3} (Taf. VII, fig. 3—cast Amer. Mus. 2572), in the K. K. Naturhistorische Hofmuseum of Vienna; a right third inferior molar, r.M_3, of an adult specimen (Taf. VIII, figs. 1, 2), in the K. K. Geologische Reichsanstalt, Vienna, also a left third superior molar, l.M^3 (p. 31, text fig. 3) in the Paläontologische Institut der Universität, Vienna. Horizon and Locality.—Wies, near Eibiswald (Styria), Austria, lower Helvetian, lower Middle Miocene.

Cotypes (Figs. 352 and 353 of the present Memoir).—The cotypes of the above species (Schlesinger, 1917, pp. 30, 31, 35, 37), as fully described and figured in Schlesinger's Memoir, are all from the lignites of Eibiswald, no single specimen being designated by the author. Consequently we may properly select as one of the cotypes highly characteristic of this important species the following figured grinding teeth: M^2, M^3 of the right side (Taf. VII, fig. 3); Schlesinger's figure of these teeth is reproduced in figure 352 of the present Memoir. Other of Schlesinger's cotypes, as enumerated above, are an M^3 of the left side (p. 31, fig. 3), a juvenile maxilla (Taf. III, fig. 2, and Taf. IV, fig. 1), and a right third inferior molar of an adult specimen (Taf. VIII, figs. 1, 2).

Cotype Description.—The cotype description is based solely on the molar teeth, as follows (*op. cit.*, p. 37): "B. *M.* (*Bl.*) *angustidens* Cuv. f. *subtapiroidea* n. f. Typus: Formen von Eibiswald.

M 3 aus je 4-4x (bisweilen 3x) Jochen, jedes aus zwei spitzen Haupthöckern, welche deutlich mehrspitzig sind. An der prätriten Hälfte nur an den vorderen Jochen je ein schwacher Sperrhöcker vorn und hinten. Die mangelhafte Ausbildung von Zwischenhöckern lässt den Zahn tapiroid erscheinen. Täler tief und ziemlich offen. Kaufiguren breit, lanzettförmig bis oval und zur Horizontalebene mehr oder weniger geneigt."

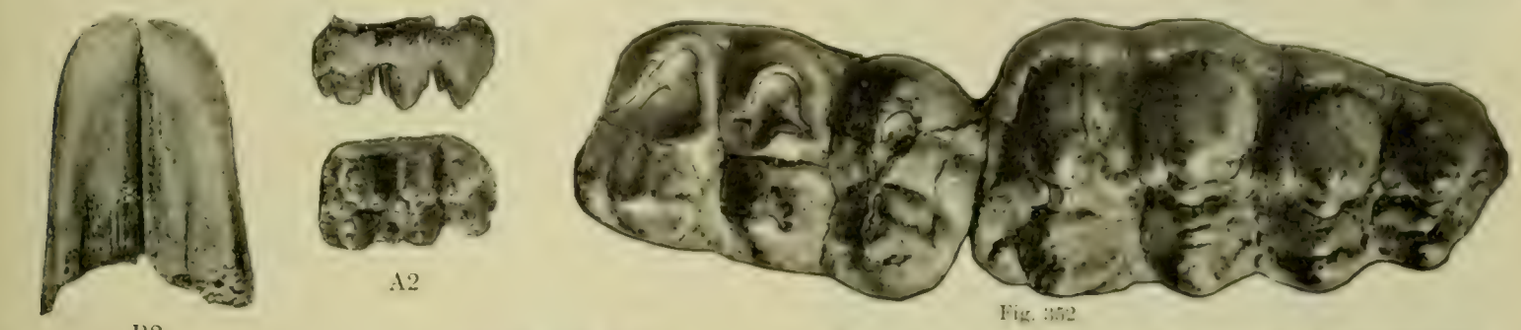


Fig. 352

Right Second and Third Superior Molars of Serridentinus subtapiroideus

Fig. 352. Cotype figure of *Serridentinus subtapiroideus* from Eibiswald (Styria), Austria, after Schlesinger, 1917, Taf. VII, fig. 3: "Abbildung 3: Maxillarrest mit M^{2+3} *dext.* von der Kaufläche. Fundort: Braunkohle von Vordersdorf bei Eibiswald (Steiermark). Horizont: Untere Helvetische Stufe des Miozäns. Wiedergabe: ½ natürl. Gr." Reduced to one-half natural size. Cast Amer. Mus. 2572.

Fig. 351

Fig. 351. Serridentinus subtapiroideus (B1, B2?); compared with Trilophodon angustidens (A1, A2) with central conules

Typical *Trilophodon:* A1,A2

A1, "*Mastodon* (*Bunolophodon*) *angustidens* Cuvier *forma typica* autorum. Abbildung 3: M_3 sin. (stark niedergekaut); man achte auf die kreisförmigen, horizontalen Kaufiguren und die mächtigen, auch noch am hinteren Hang des letzten Joches vorhandenen Sperrpfeiler. Fundort: Poysdorf (Niederösterreich), Sandgrube des Heinrich Schödl. Horizont: Grunder (=Obere Helvetische) Stufe des Miozäns. Wiedergabe: Natürl. Gr." A left third lower molar, l.M_3, of *Trilophodon angustidens*. After Schlesinger, 1917, Taf. VIII, fig. 3. One-third natural size.

A2, Right M^1 referred to *Mastodon* (*Bunolophodon*) *angustidens*, from the sands of Guntersdorf, Helvetian Miocene of Austria. After Schlesinger, 1917, Taf. II, fig. 2 (crown view), and Taf. III, fig. 1 (inner view). One-third natural size.

Serridentinus: B 1, B 2 (?)

B1, "*Mastodon* (*Bunolophodon*) *angustidens* Cuvier *forma subtapiroidea* nova forma. . . . Abbildung 3. Maxillarrest mit M^{2+3}*dext.* von der Kaufläche. Fundort: Braunkohle von Vordersdorf bei Eibiswald (Steiermark). Horizont: Untere Helvetische Stufe des Miozäns. Wiedergabe: ½ naturl. Gr." Cotype third superior molar, r.M^3, of *Serridentinus subtapiroideus*. After Schlesinger, 1917, Taf. VII, fig. 3, one-third natural size (see also Fig. 352). Cast Amer. Mus. 2572.

B2 (?), Lower incisors from lignites, Eibiswald (Steiermark), referred by Schlesinger, 1917, Taf. I, fig. 6, to *Mastodon* (*Bunolophodon*) *angustidens* [=*Serridentinus subtapiroideus*]. One-third natural size.

Comparison with Serridentinus productus (Fig. 349).—The excellent cast of the cotype specimen (Amer. Mus. 2572), presented to the American Museum by Doctor Schlesinger, enables us to place this specimen (Fig. 352) in close comparison with the teeth of *Serridentinus productus* (Fig. 349).

Characters of Cotype (Fig. 353). The *cotype* (see Fig. 353, described by Schlesinger as a subspecies, namely, "*M.* (*Bl.*) *angustidens* Cuv. f. *subtapiroidea* n. f.," is a relatively short and broad third superior grinder of the left side, l.M^3. Figure 353, after a photograph kindly loaned by Doctor Schlesinger, displays the characters of this tooth in some respects more clearly than the figure in Schlesinger, 1917, p. 31, fig. 3. This cotype tooth has three main crests, protoloph, metaloph, tritoloph, and an incomplete tetartoloph. It is excluded from *Trilophodon* by the *absence* of median conules in the center of the valleys; it shows affinity to *Turicius* by the presence of more or less serrate or denticular crests extending down the sides of the internal cones. Thus there are no median trefoils, but we find internal trefoils on the superior molars clearly seen on the protoloph and the tritoloph. The summits of the three transverse crests tend to become zygodont; both the inner and the outer cones split into two conelets, e.g., Schlesinger, 1917, p. 37. . . . "jedes aus zwei spitzen Haupthöckern, welche deutlich mehrspitzig sind." This is a primitive stage of the molar tooth pattern characteristic of the American species of *Serridentinus*.

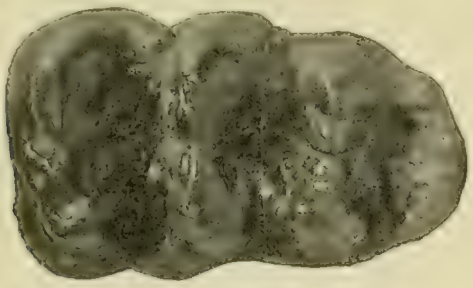
Habitat.—The animal is described by Schlesinger (*op. cit.*, p. 45) as more *zygodont* and as frequenting the *forested swamps* (*sumpfwald*) of the Miocene lignites of Styria, Wies, near Eibiswald, where a referred '*M.*' *tapiroides* Cuvier is also recorded (*op. cit.*, p. 56), also at Steinheim (*op. cit.*, p. 57). On the contrary, Sansan is regarded by Schlesinger (*op. cit.*, p. 59) as containing a *dry forest fauna* of the savanna type interspersed with larger and smaller grass meadows in which occurs the typical *T. angustidens*.

Characteristic of Lignitic Deposits (Schlesinger, 1917).—Following the type description there are in Schlesinger's Memoir of 1917 frequent references in the text and in the figure and plate legends to animals which he refers to *Mastodon* (*Bunolophodon*) *subtapiroidea*. On page 228 he compares this animal with Cope's *Mastodon productus* and *M. proavus* and with Leidy's *M. obscurus*, but he does not separate it into a distinct phylum either in the text or in his concluding review, pp. 224–230, entitled, "Zusammenfassung der phylogenetischen Ergebnisse."

In the plates (Pls. II, III, VII, and VIII) Schlesinger distinguishes between *Mastodon* (*Bunolophodon*) *angustidens forma typica*,

chiefly found in sand deposits, and *Mastodon (Bunolophodon) angustidens* var. *subtapiroidea*, chiefly found in lignitic deposits of Helvetian age, Middle Miocene. Examples of the latter are: P^3, Taf. III, fig. 2, and especially the beautiful figure of M^2, M^3, Taf. VII, fig. 3, Eibiswald (Steiermark), reproduced herewith (Figs. 352, 351, B 1), also M_3, Taf. VIII, figs. 1, 2. M^2, M^3, Eibiswald, of Taf. VII, fig. 3, measure 253.7 mm., as compared with 297 mm. in the two corresponding teeth of *Serridentinus productus* from the Clarendon, Lower Pliocene of Texas.

SCHLESINGER, 1922.—In his Memoir of 1922, Taf. VII, figs. 5–7, also fig. 9, Schlesinger adds a number of teeth from Hungary in the Budapest Museum which he refers to his species *subtapiroidea* in the legends but which appear to Osborn to belong rather to *M. angustidens forma typica*. In the same work, Taf. VIII, fig. 10, a tooth figured as belonging to *subtapiroidea* we should regard as belonging to *Pliomastodon praetypica* (Chap. VI). A similar tooth



COTYPE SUPERIOR MOLAR, LEFT M^3, OF SERRIDENTINUS SUBTAPIROIDEUS

Fig. 353. One of the cotypes of *M. (Bunolophodon) angustidens* Cuv. f. *subtapiroidea* Schlesinger, 1917, left side, l.M^3. Type loc.: Wies near Eibiswald (Steiermark), Austria; lignites, Helvetian, lower Middle Miocene. After original cotype specimen in the collection of the Palaeontological Institute, University of Vienna. Photograph loaned by Doctor Schlesinger. Reproduced one-half natural size. Compare Schlesinger, 1917, p. 31, fig. 3.

Observe that in this cotype the tetartoloph is much less strongly developed than in the cotype (Fig. 352); consequently Osborn doubts whether this cotype specimen is typical of the species.

of the right and left sides (Amer. Mus. 19152), including l.Dp_4,[1] l.M_1, r.M_{2-3}.

A generic character of *Serridentinus* is displayed (Fig. 354) in the single conelets on the external side as an ectolophid, best seen in the outer view. The specimen occurred in a thin deposit of olive-colored clays and light gray sandstone resting on the red-banded beds of the Hsanda Gol formation at Loh, now believed to be of Middle Miocene age. In the same beds occurs the small species *'Baluchitherium' mongoliense*.

Serridentinus mongoliensis Osborn, 1924. "*Serridentinus* and *Baluchitherium*, Loh Formation, Mongolia." Amer. Mus. Novitates, No. 148, November 11, 1924, pp. 1–3. TYPE.—A series of right and left inferior grinding teeth: r.M_2, r.M_3, also a left deciduous premolar, l.Dp_4, and one left grinder, l.M_1; in juvenile condition, Dp_4 greatly worn, M_1 partly worn, M_{2-3} embedded in the jaw. HORIZON AND LOCALITY.—Loh, near camp. Upper

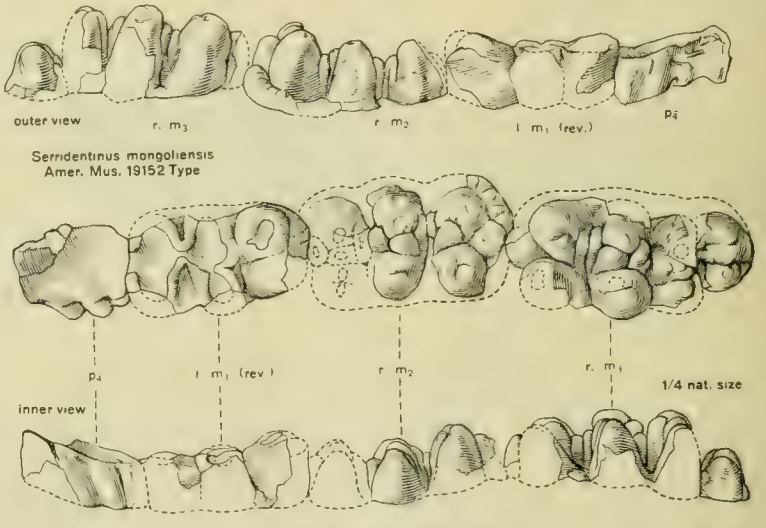


Fig. 354. Type of *Serridentinus mongoliensis* (Amer. Mus. 19152), four lower grinding teeth, P_4 (Dp_4)-M_3, Loh formation, Lower to Middle Miocene, Mongolia. After Osborn, 1924.630, fig. 1, p. 2. One-fourth natural size.

(Upper) external view. (Middle) crown view. (Lower) internal view. The teeth are from the right side, except the fourth deciduous premolar, l.Dp_4,[1] and the first molar, l.M_1 (rev.), which are from the left side.

is described as follows in the legend of Taf. XIV: "*Mastodon (Mammut) americanus* Pennant *forma praetypica* Schlesinger. Figur 5: M^2 *dext.* von der Kaufläche. *Fundort* : Rákoskeresztúr, Komitat Pest. *Horizont:* Levantin (Mittelpliozän). Wiedergabe: ½ natürl. Gr."

Serridentinus mongoliensis Osborn, 1924

Figures 350 F-F2, 354

Loh formation, Lower to Middle Miocene, Mongolia.

One of the most welcome discoveries of the Central Asiatic Expedition of 1922 was the type of *Serridentinus mongoliensis* found in the Loh formation, of Lower to Middle Miocene age, Mongolia. These lower grinding teeth serve to demonstrate the migration of a very primitive member of the phylum *Serridentinus* through the heart of northern Asia *en route* to North America. The type consists of a fragmentary series of lower grinding teeth

olive clays. Loh formation, Lower to Middle Miocene, Mongolia. Found by J. B. Shackelford, July 15, 1922, Field No. 71 (Amer. Mus. 19152). TYPE FIGURE.—*Op. cit.*, 1924.630, p. 2, fig. 1.

TYPE DESCRIPTION.—(*Op. cit.*, 1924.630, pp. 2,3): "The type specimen was found in an extremely fractured condition and was restored, as shown in figure 1. It required great skill in reconstruction; the restored parts are indicated by dotted lines. The principal measurements in millimeters, all estimated, and indices (I.) are:

p_4 (dp_4) -m_3 inc. =	420e
p_4 (dp_4), much worn,	ap. 65, tr. 51, I. .78
m_1, left,	ap. 99, tr. 58, I. .59
m_2, right,	ap. 108, tr. 59, I. .55
m_3, right,	ap. 138, tr. 63, I. .46

. . . As compared with *S. productus*, the type of *S. mongoliensis* is a smaller animal, m_{1-3} measuring 340 mm. *S. mongoliensis* is also

[1]Throughout the description of *Serridentinus mongoliensis* the fourth permanent premolar (P_4) in figure 354 is incorrectly described as an l.Dp_4.

less progressive, each loph consisting of four conelets (by reduplication of the two primary cones, corresponding with the protoconid and metaconid in each loph), and two large trefoil conules on each side of the external cones (corresponding with the protoconid). More in detail: the crown of dp_4 is entirely worn off; the crown of left m_1 is largely worn off; in the crown of m_2 the protolophid is wanting; the metalophid has the typical structure described above, namely, four conelets, two trefoil conules; in the tritolophid the cones are less distinctly paired into conelets, there is a small anterior trefoil conule and a large posterior. In the right m_3, the protolophid has a very large anterior trefoil conule, a small posterior; the metalophid is typical, consisting of four symmetrical conelets and two symmetrical trefoil conules; the tritolophid is less progressive; the tetartolophid is depressed and consists of three main conelets. These specific characters may be verified by applying the magnifying lens to figure 1 [Fig. 354 of the present Memoir]."

"Specific Characters.—Ridgecrest formula of *S. mongoliensis:* P $4\frac{}{2+}$ M $1\frac{}{3}$ M $2\frac{}{3}$ M $3\frac{}{1}$. In each typical ridgecrest (e.g., the metalophid) three [four] conelets and two trefoil conules attached to the external cones. Molar proportions as in *S. productus.*"

Osborn, 1926: The observations in the above quotation of the original description of 1924 are entirely confirmed by subsequent studies. This Mongolian species certainly belongs in the genus *Serridentinus;* furthermore, it belongs in series A in which the cones and conelets have excessively obtuse, rounded summits. In the type figure (Fig. 354) both the fourth lower deciduous premolar and the first lower molar probably belong in the left jaw.

Ocalientinus (Serridentinus) florescens Osborn, 1929

Figure 355

Kholobolchi Nor region, Mongolia, five to eight miles north of camp. Khunuk formation, Pliocene, possibly equivalent to the Hung Kureh beds of the Tsagan Nor region.

Serridentinus[1] *florescens* Osborn, 1929. "New Eurasiatic and American Proboscideans," Amer. Mus. Novitates, No. 393, 1929, p. 6 (Osborn, 1929.797). Type.—Second inferior molar of the right side, r.M_2, crushed laterally. Collected by Walter Granger on June 30, 1925; Amer. Mus. 21615, Field No. 543. Horizon and Locality.—Kholobolchi Nor region, Mongolia, five to eight miles north of camp, Khunuk formation, Pliocene, possibly equivalent to the Hung Kureh beds of the Tsagan Nor region. Type Figure.—*Op. cit.*, Osborn, 1929.797, p. 7, fig. 7.

The specific name *florescens* refers to the remarkable florescence or blossoming out of the external trefoil spurs into broad anteroposterior plates crowned with four to five conelets which greatly exceed in prominence those of any other species of *Serridentinus.* The type tooth was first regarded as akin to *Serridentinus mongoliensis,* but on examination (see Fig. 355) it appears that this unique molar has progressed far beyond *S. mongoliensis* (Fig. 354) in the elevation and elaboration of the outer cones which apparently rise above the inner cones (Fig. 355A). The length of the type crown (131e mm.) exceeds that of r.M_2 in *S. mongoliensis* (108 mm.); the breadth of the tritolophid is 45+ mm. and is greatly contracted by lateral crushing; the estimated height of the three internal cones (45e mm.) exceeds the height of the internal cones of *S. mongoliensis* (40e mm.); the summit of the external cones and spurs (50e mm.) exceeds that of *S. mongoliensis* (42e mm.). Consequently this second inferior molar of *S. florescens* represents an individual about one-fifth larger than the type individual of *S. mongoliensis.* The anterior border gives rise to a low cingulum; the tooth is apparently broader behind; the posterior border terminates with a low postero-

Type of Ocalientinus (Serridentinus) florescens

Fig. 355. Type of *Serridentinus florescens*[1] Osborn. A second inferior molar of the right side, r.M_2 (Amer. Mus. 21615), from the Kholobolchi Nor region, Khunuk formation, Pliocene, Mongolia. Reduced to about two-thirds natural size. Laterally crushed; actual length 131e mm.

A, Internal aspect, anterior surface of the crown to the left, exhibiting three large internal cones and florescent external crests.

B, External aspect of same tooth, with anterior surface of the crown to the right, showing partly fractured external crests.

After Osborn, 1929.797, p. 7, fig. 7.

internal conelet; the internal cones are bifid, supporting a large inner and lesser median conelet; the external cones are compressed transversely and expanded anteroposteriorly rising to a central apex, with one anterior and three posterior conelets on the trefoil spurs.

Ocalientinus (*Ser.*) *florescens* appears to represent a progressive stage in the evolution of the serrated crests of the ectoconelets, comparable with those of *O.* (*S.*) *floridanus,* as shown in Fig. 379, p. 417, below.

Geology.—The type was collected by Dr. Walter Granger, who gives the following description of the locality and level:

In the Kholobolchi Nor region of Mongolia there are three areas of late deposits considered, in the field, as being of Pleistocene age; the geologists were of the opinion that these three exposures were of the same age, and the name "Khunuk" was given to the formation. The three exposures mentioned in the Kholobolchi Nor region are respectively north, northeast, and east of the lake; the type of *Serridentinus florescens*[1] comes from the northern exposure of the "Khunuk" and represents the only specimen obtained in that particular locality.

[1]Referred (1935) to the genus *Ocalientinus.*

Serridentinus gobiensis Osborn and Granger, 1932

Figures 357 and 286G, G1

From the Tung Gur Upper Miocene beds, about forty miles southeast of Iren Dabasu, Inner Mongolia.

The type of this species was discovered in 1930 by Roy Chapman Andrews, chief of the Central Asiatic Expedition, on the western edge of the Tung Gur tableland (Fig. 356) in the Tung Gur formation, *Platybelodon grangeri* life zone, now regarded as of Upper Miocene age.

Associated with these Platybelodonts or 'flat-tuskers' was the type specimen (Amer. Mus. 26461) of the genus *Serridentinus* described by Osborn and Granger (1932.886) as *Serridentinus gobiensis*, a welcome addition to the Serridentine fauna of the ancient Gobi, to which the species *Serridentinus* [*Ocalientinus*] *florescens* was previously referred.

Serridentinus gobiensis Osborn and Granger, 1932. "Platybelodon grangeri, Three Growth Stages, and a New Serridentine from Mongolia," Amer. Mus. Novitates, No. 537, 1932, pp. 11–13. TYPE.—"A finely preserved right ramus of the lower jaw supporting M_{2-3} and with complete symphysis and both incisors." Amer. Mus. 26461. HORIZON AND LOCALITY.—From the Tung Gur Upper Miocene beds, about forty miles southeast of Iren Dabasu, Inner Mongolia. TYPE FIGURE.—*Op. cit.*, Osborn, 1932.886, p. 12, fig. 8.

SPECIFIC CHARACTERS OF S. GOBIENSIS.—Extreme length of ramus from tip of incisor tooth to posterior border = 1090 mm. Extension of lower incisor beyond alveolar border = 125 mm. Greatest diameter of tusk at alveolar border = 50 mm. M_2, ap. 125 mm., tr. 85 mm. M_3, ap. 195 mm., tr. 87 mm. The lower border of the ramus, from the alveolar edge to the angle of the jaw, is a nearly straight line which is set off at an angle of about 15° from the plane of the molar crowns. Lower tusks rounded on the lower and outer surface and somewhat flattened on the lingual face. M_2 with three ridges, M_3 with four ridges and a heel. Serrated spur-crests or molar borders. Molar pattern extremely simple and lophodont.

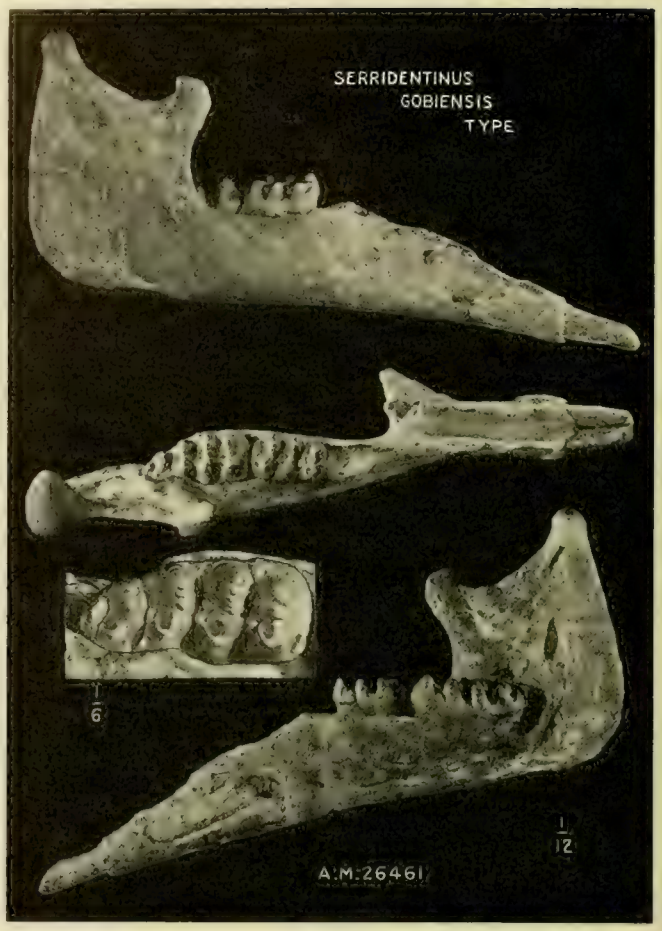
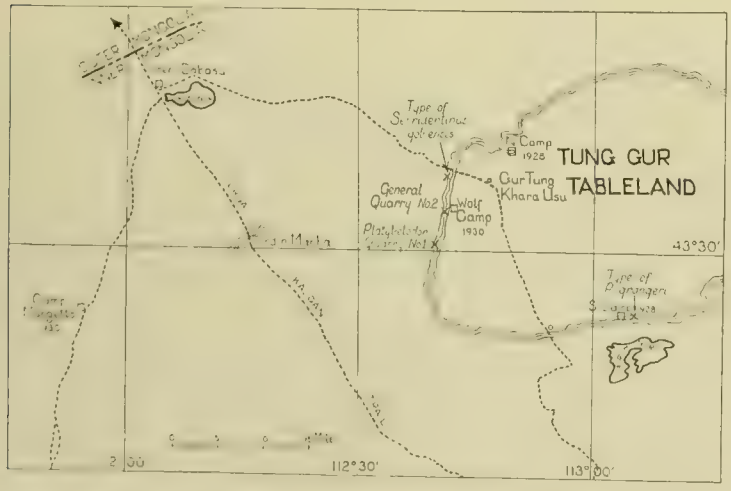


Fig. 357. Type of *Serridentinus gobiensis* Osborn and Granger, 1932, p. 12, fig. 8. Amer. Mus. 26461. From the Tung Gur formation, Upper Miocene.

An isolated adult specimen exhibiting the rodlike inferior incisors; M_2 with three ridge-crests, M_3 with four and a third ridge-crests. Three aspects of the mandible after retouched photograph, one-twelfth natural size. Inset—retouched photograph of r.M_3 exhibiting the crescentic external spurs characteristic of the genus *Serridentinus;* one-sixth natural size.



SKETCH MAP OF THE REGION AROUND IREN DABASU, INNER MONGOLIA

Fig. 356. The two working camps of the 1930 Central Asiatic Expedition are here shown in Wolf Camp in the Upper Miocene (*Platybelodon*) beds of the Tung Gur tableland and Camp Margetts to the westward in the Upper Eocene (Irdin Manha) and mid-Oligocene (Houldjin Gravels). After Osborn and Granger (Osborn, 1932.886, fig. 1).

Serridentinus gobiensis may be compared with other trilophodonts from Central Asia. From *Trilophodon* (*Serridentinus*?) *inopinatus* Borissiak it differs in its much greater size—the M_3 being about one-third longer—and in the presence of an extra half-loph on M_3. The rather highly elevated condyle and coronoid in *S. gobiensis* is a further distinction from Borissiak's form. From *S. mongoliensis* Osborn, from the Loh formation, and *Ocal.* (*S.*) *florescens* Osborn from the Khunuk beds, both of the western Gobi, this species *S. gobiensis* is readily distinguishable by the simplicity of the molar pattern. It is without much doubt older geologically than *O.* (*S.*) *florescens*, which is probably not older than the Pliocene.

Serridentinus gobiensis is in a stage of evolution closely similar to that of the Miocene *S. subtapiroideus* of Eibiswald (Styria), Austria, contemporaneous in France with Sansan and Simorre. Compared with *S. subtapiroideus* Schlesinger (Figs. 351, B1, and

352), in which M^3 measures 150 mm., the third inferior molar, M_3, of *Serridentinus gobiensis* measures 195 mm.; the rudiment of the fifth crest or pentaloph observed in M^3 of *S. subtapiroideus* (Fig. 352) naturally would correlate with the distinct, conical pentalophid talon in M_3 of *S. gobiensis*.

Serridentinus with its small sub-rounded tusks probably had quite different food habits and consequently a different local range from its geologic contemporary, *Platybelodon grangeri*. It was an 'uproot-tusker.' The fact that, aside from a few tooth fragments, the type jaw of *Serridentinus gobiensis* is the only mastodont, other than *Platybelodon*, found in the Tung Gur regions would indicate that either it was a relatively rare form or that its main habitat was different from that of the 'flat-tuskers.'

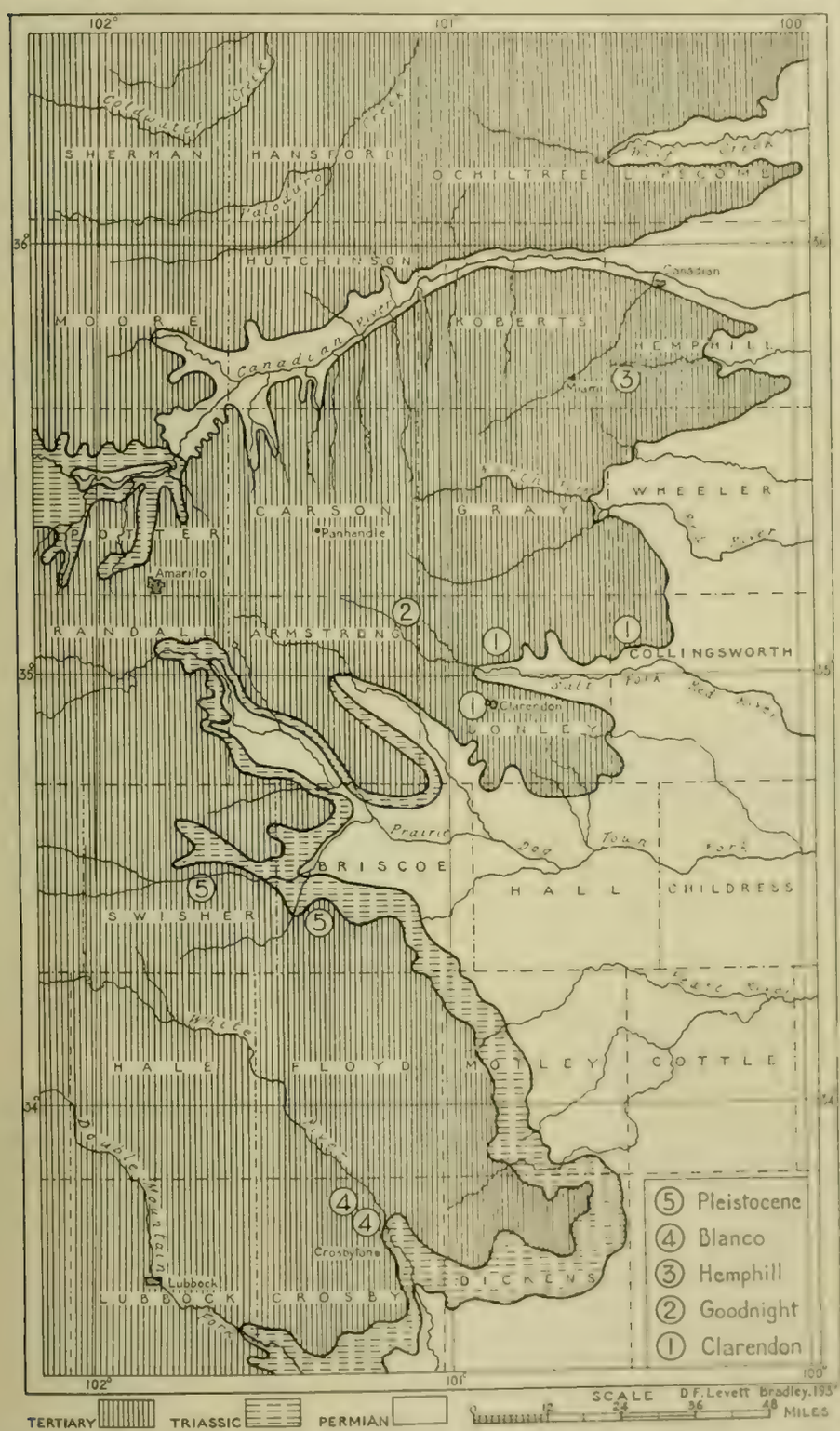


Fig. 358. Pliocene and Lower Pleistocene Proboscidea, Perissodactyla, Artiodactyla, and Edentata of the Staked Plains of Texas.[1]

	Pliocene					
	Clarendon	Goodnight	Hemphill	Blanco	San Pedro	Plio-Pleistocene
PROBOSCIDEA						
Serridentinus productus Ref.	×					
Trilophodon brazosius Type						×
Serridentinus serridens Type	×					
Serbelodon(?) praecursor Type				×		
Rhynchotherium falconeri Type				×		
Rhynchotherium sp.			×			
Stegomastodon mirificus Ref.						×
Stegomastodon texanus Type				×		
Stegomastodon successor Type						
Stegomastodon arizonae Type					×	
Cordillerion defloccatus Type						·
Cordillerion gratum Type						·
Cordillerion orarius Type						·
Cordillerion bensonensis Type					·	
Archidiskodon (?)nebrascensis Ref.						×
Mastodon progenius Ref.						×
Mastodon americanus Ref.						×
Tetralophodon fricki Type	?×					
PERISSODACTYLA						
Teleoceras fossiger	·					
Aphelops cf. *mutilus*		·				
Protohippus perditus	×					
Pliohippus fossulatus	×					
Plesippus cumminsii				×		
Plesippus simplicidens				×		
Hipparion phlegon				×		
Hipparion eurystylum	×					
Hipparion lenticulare	×					
Hipparion affine	×					
Hipparion occidentale	×					
Equus excelsus						·
Equus giganteus						·
ARTIODACTYLA						
Procamelus robustus	·					
Pliauchenia spatula				·		
Camelops hesternus						·
Platygonus bicalcaratus				·		
EDENTATA						
Glyptotherium texanum				·		
Glyptotherium arizonae					·	
Megatherium mirabile						×
Megalonyx leptostomus				·		
Mylodon harlani						×

[1]This is a preliminary list. A more complete list will be given in Volume II, Chapter XVI (*Archidiskodon*). While the accompanying map does not include Arizona, where the San Pedro beds are located, a column has been inserted showing the Proboscidea of these beds; the associated fauna is omitted.

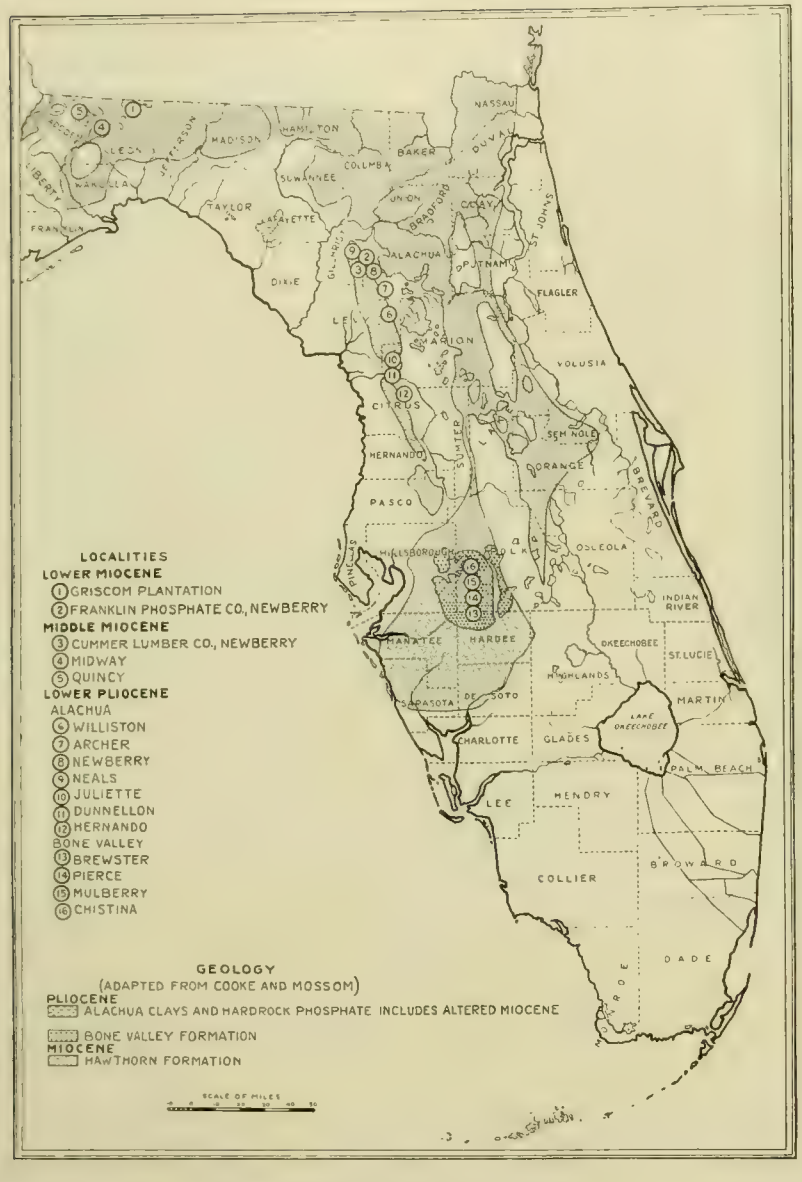


Fig. 359. Mio-Pliocene Tertiaries of Florida. After Simpson, 1930, p. 152, Fig. 1. Adapted from Cooke and Mossom.

Fossil fauna of Florida, from Lower Miocene to Upper Pleistocene time; chiefly due to studies of Dall (1887–1896), Leidy and Lucas (1884–1896, 1899), Cope (1889–1896), Gidley (1891, 1913, 1926, 1928), Matthew (1909–1924), Osborn (1909, 1910), Sellards (1910–1924), Chamberlin (1917), Holmes (1924–1926), Loomis (1924, 1925), Cooke (1926, 1928), Cooke and Mossom (1929), Simpson (1928–1933).

Hawthorn formation. Highly characteristic Lower-Middle Miocene equines: (*Anchitherium-Hypohippus*), *Archæohippus*, *Parahippus*, *Merychippus* (3 sp.). Cameloids: *Oxydactylus*, *?Miolabis*. Canids: *Cynodesmus*, *Amphicyon*. Tragulids and cervids: *?Leptomeryx*, *Blastomeryx*. Oreodont: ?sp. Rhinoceroids: Hornless rhinoceros (*Aphelops*). Western correlation = Upper Harrison-Rosebud-Sheep Creek, Lower and Middle Miocene of Nebraska and South Dakota. No Proboscideans.

Alachua formation. Lower Pliocene. First Mastodonts: (*Ocalientinus* (*Ser.*) *floridanus* abundant; *O.* (*S.*) *flor. leidii* also occurs. Equines: *Hipparion ingenuum*, *H. plicatile*, *H. minor*. Cameloids: *?Megatylopus major*, *?Procamelus minor*, *?P. minimus*. Rhinoceroids: *Aphelops longipes*, *Teleoceras proterus*. Loc.: Archer, Williston, Newberry, Neals, Juliette, Dunnellon, Hernando. Western correlation = late Miocene-Lower Pliocene, Upper Snake Creek, W. Nebraska, Republican River, Kansas.

Bone Valley formation, pebble phosphates; same age as Alachua hard rock phosphates. Mastodonts: *Ocalientinus* (*Ser.*) *floridanus*, *Ser. brewsterensis*, *O.* ? (*S.*) *obliquidens*, *Trilophodon simplicidens*, *Pliomastodon sellardsi* (cf. *P. matthewi*, Upper Snake Creek). Equines: *Hipparion ingenuum*, *H. plicatile*, *H. minor*, *H. phosphorum*. Rhinoceroids: *Aphelops longipes*, *Teleoceras proterus*. Cameloids: Indet. Canids: *Agriotherium* (cf. Eden, Calif., *A gregori*). Procyonids: *Leptarctus*.

Melbourne. Lower to Middle Pleistocene, including 'Peace Creek' or 'Peace River'; Seminole (Holmes, 1924–1926), Pinellas Co., W. Florida; Sarasota Co.; Manatee Co., Bradenton (*Parelephas floridanus*); predominantly Pleistocene with derived Pliocene fossils, e.g., *Hipparion*. Mastodonts: *Mastodon americanus*. First Elephantoids: *Parelephas columbi* (Melbourne, Vero, East Florida), *Archidiskodon imperator* (Melbourne, Venice). Equines: *Equus complicatus*, *E. leidii*. Tapiroids: *Tap. veroensis*. Peccaries: *Mylohyus gidleyi*. Edentates: *Megalonyx* (cf. *jeffersoni*), *Mylodon* (cf. *harlani*). Armadillos: *Tatu bellus*, *Chlamytherium septentrionale*. Glyptodont: *Boreostracon floridanus*.

Age	Mammal-Bearing Formations		Typical Genera
RECENT	Beach, river, swamp, and æolian		Recent: *Odocoileus*, *Lynx*, *Procyon*, *Didelphis*, *Neofiber*, also derived Plio-Pleistocene fossils.
PLEISTOCENE	Melbourne		*Equus*, *Mastodon*, *Parelephas*, *Archidiskodon*, *Smilodon*, *Tanupolama*, *Boreostracon*, etc., also derived Pliocene fossils.
	Anastasia, etc.		Marine, almost barren of vertebrates, but proboscideans occur.
PLIOCENE	Bone Valley: Brewster, Pierce, Mulberry, Christina	Alachua: Williston, Archer, Newberry, Neals, Juliette, Dunnellon, Hernando	Bone Valley and Alachua, nearly pure Lower Pliocene fauna. Hard rock and land pebble phosphates. *Hipparion*, *Serridentinus*, *Ocalientinus*, *Trilophodon*, *Pliomastodon*. *Teleoceras*, *Aphelops*, *Agriotherium*, also derived Miocene fossils reworked in Pliocene and later times.
MIOCENE	Hawthorn	B Middle Miocene: Newberry, Midway, Quincy	Unified formation, with distinctive faunas at different levels. B, Middle Miocene: *Merychippus*, *Amphicyon*, etc.
		A Lower Miocene: Gilchrist County, Near Tallahassee, Newberry	A, Lower Miocene: *Parahippus*, *Dinohyus*, *Cynodesmus*, etc.
OLIGOCENE			No mammals yet discovered.
EOCENE	Ocala Limestone		*Basilosaurus* (*Zeuglodon*). No land mammals.

Serridentinus progressus Osborn, 1923

Figures 171, 188, 282, 343, 360, 361, 369

Pliocene (?), Driftwood Creek, Hitchcock County, Nebraska.

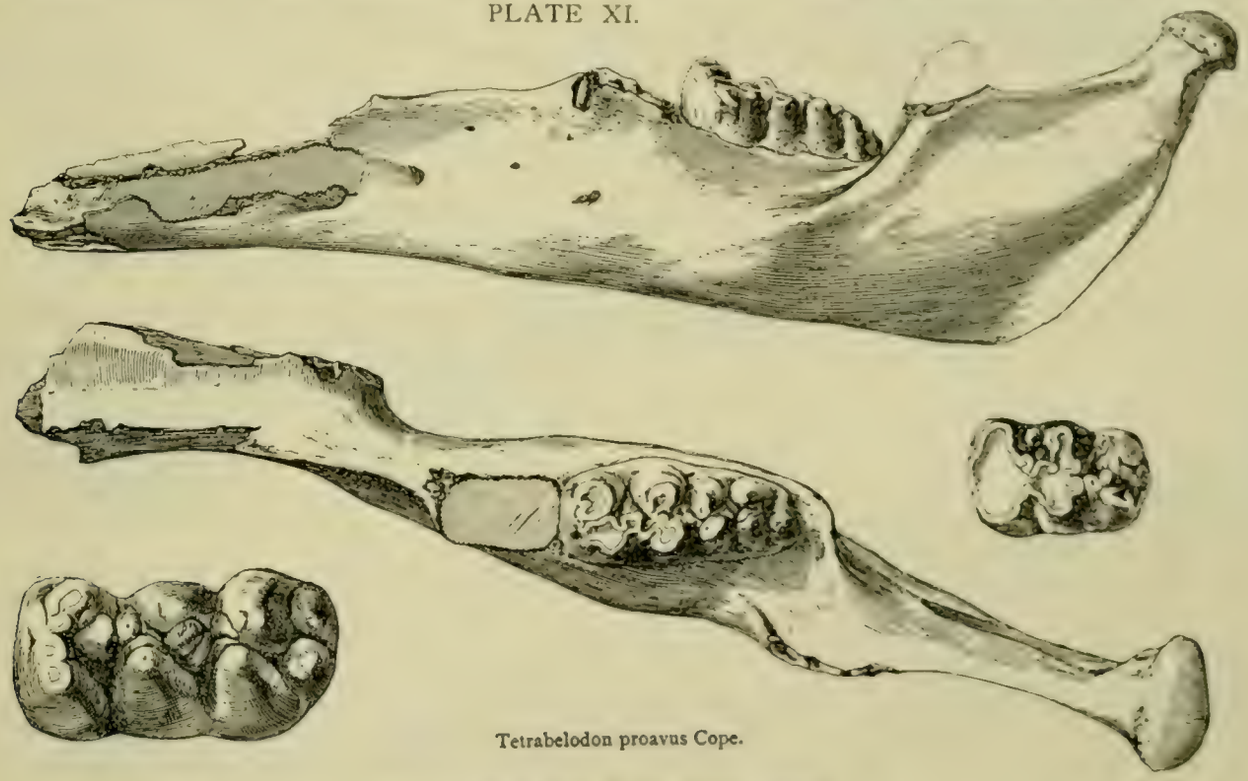
Originally described (Osborn, 1923.601, p. 3) as *Trilophodon progressus*, this type ramus is redefined as *Serridentinus progressus;* in M_3 the ectoconelets give off the characteristic serridentine spur; the mesoconelets are correspondingly reduced; there are no central conules such as characterize *Trilophodon*.

Osborn's original description of this species is as follows:

Trilophodon progressus Osborn, 1923. "New Subfamily, Generic, and Specific Stages in the Evolution of the Proboscidea." Amer. Mus. Novitates, No. 99, December 27, 1923, p. 3. elongation or hypsodonty of the lophs, and points towards the still more hypsodont stages, *Trilophodon giganteus* Osborn and *T. ligoniferus* Cope-Matthew."

The *type* of this hyperlongirostral stage (Figs. 360, 361) is a left ramus of the lower jaw (Amer. Mus. Cope Coll. 8529), from Driftwood Creek, Hitchcock County, Nebraska. It is the same specimen that Cope figured as "*Tetrabelodon proavus*" in his revision of the Proboscidea (Cope, 1889.2, p. 202, Pl. xi), under the impression that it was related to his species *Mastodon proavus* of Pawnee Buttes, Upper Miocene of Colorado, which Osborn considers as belonging to *Serridentinus proavus;* for internal view of this jaw, see figure 282 B; for crown view of the third inferior molar, figure 343, for the same crown view, more detailed, figure 361. The above figures enable us to compare this type precisely with the medilongirostral *S. productus* (Fig. 369 C) and the hyperlongirostral *T. giganteus* (Figs. 171 and 259). The dental measurements and indices are as follows:

PLATE XI.



TYPE OF SERRIDENTINUS PROGRESSUS OSBORN

Fig. 360. Type left mandibular ramus of *Trilophodon progressus* Osborn, 1923 (Amer. Mus. Cope Coll. 8529). After Cope's figure erroneously referred to "*Tetrabelodon proavus*" (Cope, 1889.2, p. 202, Pl. xi). From Driftwood Creek, Hitchcock County, Nebraska. Compare corrected figure of same jaw (Fig. 361A1).

TYPE.—A left ramus of the lower jaw (Amer. Mus. Cope Coll. 8529). HORIZON AND LOCALITY.—Pliocene (?), Driftwood Creek, Hitchcock County, Nebraska. TYPE FIGURE.—Figures 360 and 361 of the present Memoir.

TYPE DESCRIPTION.—(*Op. cit.*, 1923.601, p. 3): "The type of this hyperlongirostral specific stage is a left ramus of the lower jaw (Amer. Mus. Cope Coll. 8529), from Driftwood Creek, Hitchcock County, Nebraska, the same specimen having been figured by Cope as '*Tetrabelodon proavus*' in his revision of the Proboscidea. The ridge formula is the same as in the typical *Trilophodon angustidens*, namely: $M3\frac{4}{4\ 1/2}$. This tooth, however, exhibits a very marked evolution beyond the typical *T. angustidens* in the vertical

M_2	M_3		
	ap.	tr.	I.
Incomplete	201c	88	44c

In figure 361 is shown the right third inferior molar, r.M_3, of the type (Amer. Mus. Cope Coll. 8529) as it appears from above in the ramus (A1), also as it appears when enlarged in de-

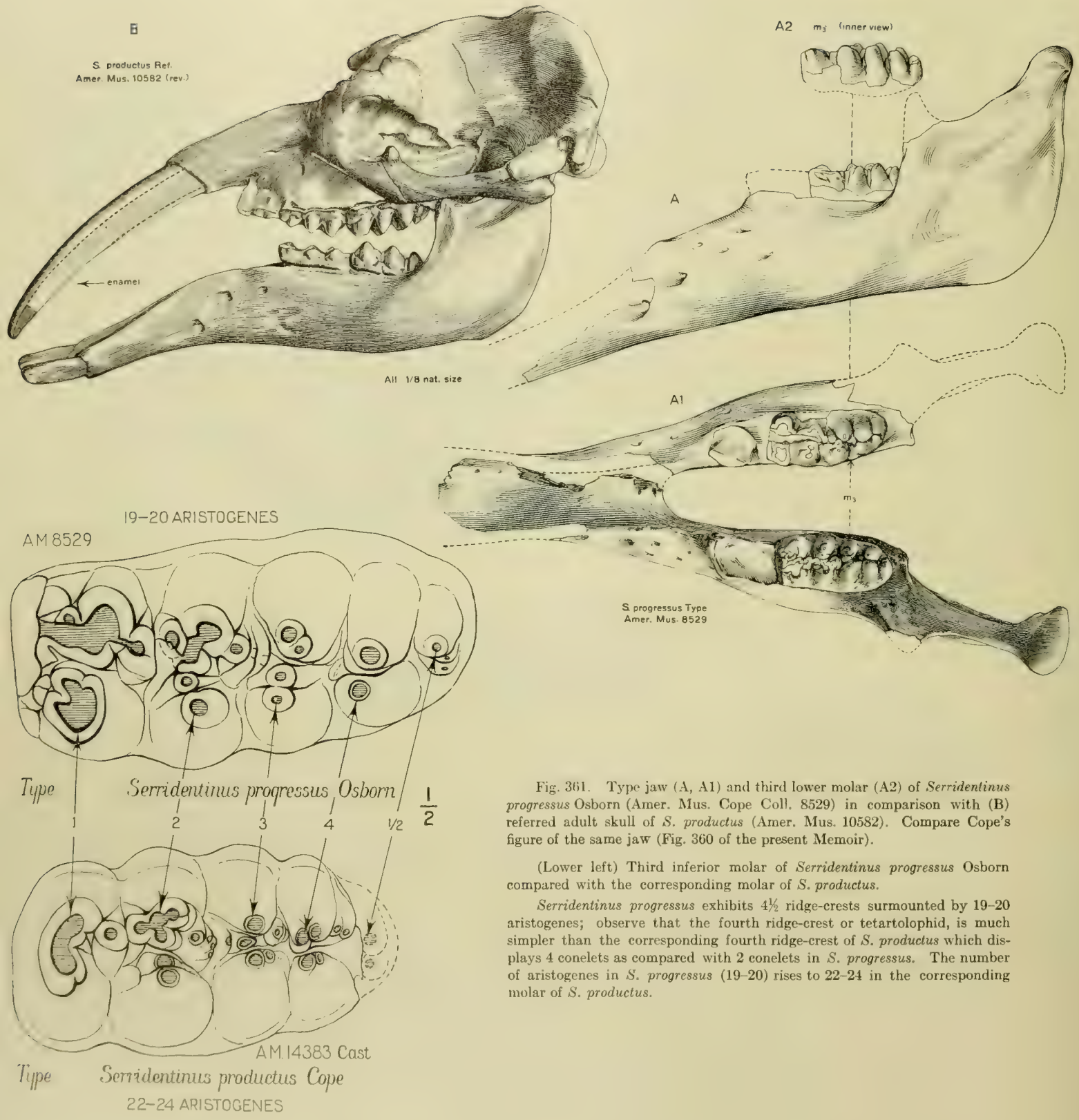


Fig. 361. Type jaw (A, A1) and third lower molar (A2) of *Serridentinus progressus* Osborn (Amer. Mus. Cope Coll. 8529) in comparison with (B) referred adult skull of *S. productus* (Amer. Mus. 10582). Compare Cope's figure of the same jaw (Fig. 360 of the present Memoir).

(Lower left) Third inferior molar of *Serridentinus progressus* Osborn compared with the corresponding molar of *S. productus.*

Serridentinus progressus exhibits 4½ ridge-crests surmounted by 19–20 aristogenes; observe that the fourth ridge-crest or tetartolophid, is much simpler than the corresponding fourth ridge-crest of *S. productus* which displays 4 conelets as compared with 2 conelets in *S. progressus.* The number of aristogenes in *S. progressus* (19–20) rises to 22–24 in the corresponding molar of *S. productus.*

tailed comparison with *Serridentinus productus*; in the diagram the trefoil spurs certainly arise from the *ectoconelets* of M_3 and are not 'central conules' as they first appeared to be; the marked progression over *S. productus* is clearly shown.

It would appear that these three species may mark three ascending stages in different lines of ascent:

	Total length	Total width	Index	Height of tritolophid above base of crown
T. ligoniferus type, M_3	245	92	38	65
T. giganteus type, M_3	172	91	53	70e
S. progressus type, M_3	201e	88	44e	70

Osborn, 1933: According to the above measurements and indices, *Serridentinus progressus* is really inferior in dimensions and in hypsodonty to both *T. giganteus* and *T. ligoniferus*. As shown in figure 361, the type of *S. progressus* with 19–20 aristogenes is less progressive than the type of *S. productus* with 22–24 aristogenes.

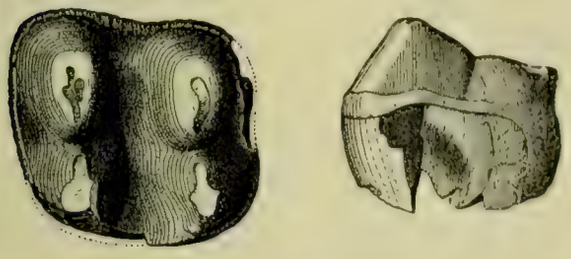


Fig. 6. *Tetrabelodon angustidens proavus* Cope; typical specimen from the Loup Fork bed of Colorado, two-thirds natural size. Original.

Type of Serridentinus proavus

Fig. 362. Original figure of type r.P^4 of *Mastodon proavus* Cope, 1873, two-thirds natural size. Pawnee Creek beds, Colorado. After Cope, 1889.2, p. 202, fig. 6, originally figured as *Tetrabelodon angustidens proavus*. Amer. Mus. Cope Coll. 8523.

Serridentinus proavus Cope, 1873

Figures 362, 363

Upper Miocene, Pawnee Buttes, Pawnee Creek (B), Weld County, Colorado.

This species (Figs. 362, 363) rests upon: A complete fourth superior premolar of the right side, r.P^4; portion of an internal cone of a superior molar of the right side, r.M^1, and probably a left astragalus; which are now recognized as the types of *Mastodon* [=*Serridentinus*] *proavus* Cope, of approximately the same geologic age as the *Serridentinus productus* of the Santa Fé marls. The measurements are given below.

Geologic Age.—The typical (lower) Pawnee Creek beds (*Merychippus sejunctus* zone) of the late Middle Miocene yield traces of mastodon, fragments of a humerus and tooth, and part of a lower jaw found at the head of Two Mile Creek (F. B. Loomis, letter of November 5, 1920). The (upper) Pawnee Creek beds (*Protohippus* zone), perhaps early Pliocene, also yield simple grinding teeth similar to the type of *M. proavus* (F. B. Loomis, 1921). We cannot be certain whether the type of '*Mastodon*' *proavus* comes from the lower '*Merychippus sejunctus*' or from the upper '*Protohippus*' zone of the Pawnee Creek.

History.—In the Upper Miocene of Pawnee Buttes, Colorado, Cope collected his fragmentary teeth of '*Mastodon*' *proavus* including a fourth superior premolar, r.P^4 (type, Fig. 362), also a portion of the internal cone of a superior molar, r.M^1, and probably a left astragalus. He did not subsequently clarify this species, for in April, 1889, p. 202, he figured (*op. cit.*, fig. 6) the type premolar under the name *Tetrabelodon angustidens proavus*, and erroneously referred a lower jaw to it (*op. cit.*, Pl. xi), a jaw which Osborn has since made the type of *Trilophodon* [=*Serridentinus*] *progressus* (see Fig. 360). Osborn now demonstrates that these teeth belong to the genus *Serridentinus*, consequently to the species *Serridentinus proavus*.

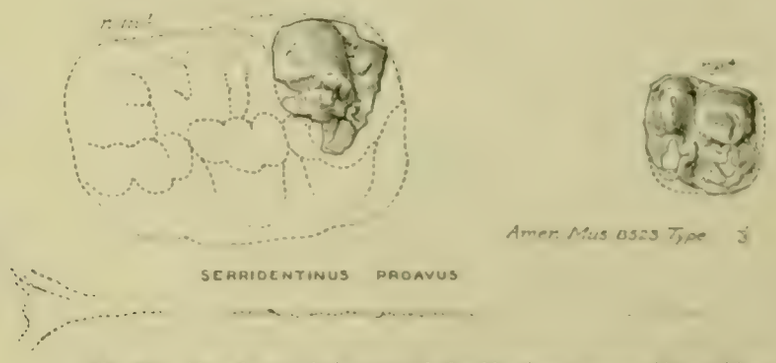


Fig. 363. New figure of the type of *Serridentinus proavus* (Amer. Mus. Cope Coll. 8523), from Pawnee Creek beds, Colorado, for comparison with Cope's original type figure. Right fourth superior premolar, r.P^4, and fragment of right first superior molar, r.M^1. Observe the trefoil rudiments on the internal side of r.P^4.

Mastodon proavus Cope, 1873. "Synopsis of New Vertebrata from the Tertiary of Colorado obtained during the Summer of 1873," October 16, 1873, p. 10. Type.—(*Op. cit.*, 1873.2, p. 10): "Represented by an entire anterior molar, portions of posterior molars, and an astragalus, all found associated by the writer. They probably pertain to the same individual." (Cope, 1889.2, p. 203, footnote): . . . "originally represented by a penultimate milk molar, with two cross-crests, and the fragments of a probable last premolar." Amer. Mus. Cope Coll. 8523. Horizon and Locality.—Collected by Cope, Hayden Survey of summer of 1873, at Pawnee Buttes, Pawnee Creek, Weld County, Colorado. Upper Miocene. Type Figure.—Cope, 1889.2, p. 202, fig. 6, under the name *Tetrabelodon angustidens proavus*.

Type Description (Cope, 1873.2, pp. 10, 11).—(1) Each crest composed of two obtuse lobes. (2) Valleys open and spreading as in *M. ohioticus*. (3) No intermediate or accessory lobes or cones. (4) Lateral and posterior cingula. (5) Length .055 m., width .050 m., elevation of cones .025 m., astragalus, transverse diameter, .100 m., long diameter .093 m.

Osborn, 1921: In 1921 Osborn suggested that the type tooth might belong to *M.* (=*Rhynchotherium*) *brevidens*.

Osborn (1922.564, p. 4).—In 1922 Osborn suggested that it might be a true member of the Mastodontinæ, referable to the genus *Miomastodon*: "*Mastodon proavus* Cope, 1873, late Middle Miocene, Pawnee Creek, Colorado=*Miomastodon proavus*. . . . . It is probable that the so-called '*Mastodon*' *proavus* of Cope from the Middle Miocene of Pawnee Creek, Colorado, is another representative of the genus *Miomastodon;* on the other hand, '*Mastodon*' *brevidens* Cope, 1889, from the late Middle Miocene, from the Deep River beds of Montana, probably belongs to the genus *Rhynchotherium*, distinguished by short molar teeth (hence *R. brevidens*) and internal lobes bearing trefoils on crests one and two."

Osborn, 1924: Osborn perceived the true relationships of this type to the genus *Serridentinus*, as clearly shown in the accompanying new figure (Fig. 363); consequently *Mastodon proavus* Cope, 1873, becomes a representative of the Upper Miocene or Lower Pliocene specific stage of this genus in America. The fragmentary type of *M. proavus* may now be confidently referred to the genus *Serridentinus*, in view of the similarity of the type to the corresponding teeth in the geologically more recent *Serridentinus serridens* ref. (Amer. Mus. 10673).

Measurements	*S. proavus* Type (Amer. Mus. Cope Coll. 8523)			*S. serridens* Ref. (Amer. Mus. 10673)			
	ap.	tr.	I.	ap.	tr.	I.	
Fourth superior premolar, r.P⁴	52	47	90	60	50	83	(l. P⁴)
				51	51	100	(r. P⁴)
Height of entoloph cone in r.M¹		50					
Height of entoloph cone in P⁴		23					
Width astragalar facet for tibia and fibula		77					
Width astragalar facet, antero-posterior		75					
Width astragalo-navicular facet		61					
Width astragalo-calcaneal facet		68					

The fourth upper premolar, r.P⁴, is composed of a pair of lobate anterior and posterior ridge-crests, each consisting of a smoothly rounded external lobe and of an antero-internal lobe from which a trefoil spur ascends on the anterior border, the posterior border being smooth, as are also the sides of the postero-internal lobe. As also shown in figure 363, the supposed postero-internal cone of M¹ exhibits two very distinct trefoil spurs, one on the anterior and one on the posterior slope. It is these internal trefoil ridges and the absence of central conules that establish the affinities of these teeth to the corresponding teeth of *Serridentinus serridens*, as shown in the accompanying figures.

DISTINCTION BETWEEN SERRIDENTINUS PRODUCTUS AND S. SERRIDENS (FIG. 364)

The mature cranium of *Serridentinus productus* (A), with the third molar, M³, in function, is relatively much more primitive than the young adult cranium of *S. serridens* (B) in which P 4–M 2 are functioning while M 3 is still buried in the jaw. Consequently *S. serridens* is a much larger and more progressive species with a very broad palatal-pterygoid region and large distinct occipital condyles. *S. productus* may be fully described first; the more progressive *S. serridens* leads into the sharp-crested Serridentines of the arid plateaus.

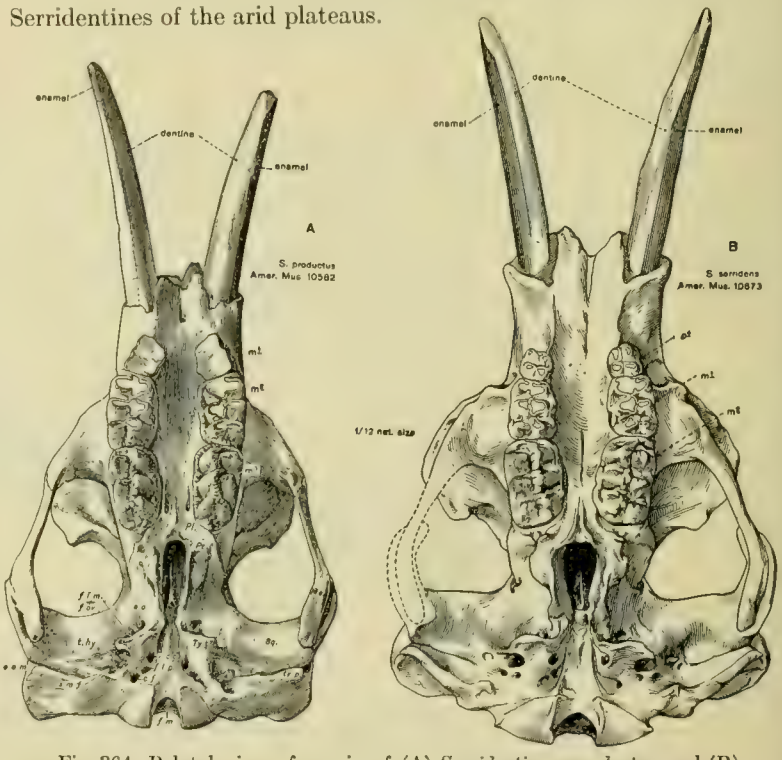


Fig. 364. Palatal view of crania of (A) *Serridentinus productus* and (B) *S. serridens* compared, one-twelfth natural size.

A, Referred *Serridentinus productus* palate (Amer. Mus. 10582) fully described below in the present chapter. This is an adult cranium with M¹⁻³ functional. Observe the simple postpalatine area, pterygoids, and posterior nares, apparently adapted to a less vigorous and muscular jaw than in *S. serridens*, in correlation with a more succulent diet and with more rounded cones and conelets.

B, Younger skull of *Serridentinus serridens* ref. (Amer. Mus. 10673), with P⁴-M² functional, M³ still buried in the cranium. Observe the broad palatal-pterygoid-postnarial region, adapted to heavy musculature as compared with *S. productus* (A); observe also the broad, spreading, laterally acute shape of the occipital condyles as compared with the more closely compressed condyles of *S. productus* (A). This cranium is a type that we should expect to find in Adaptation B series of *Serridentinus*, adapted to dry, arid plateau conditions of life.

Serridentinus productus Cope, 1875

Figures 170–177, 281, 282, 341, 347, 349, 350, 361, 364, 365, 367–372

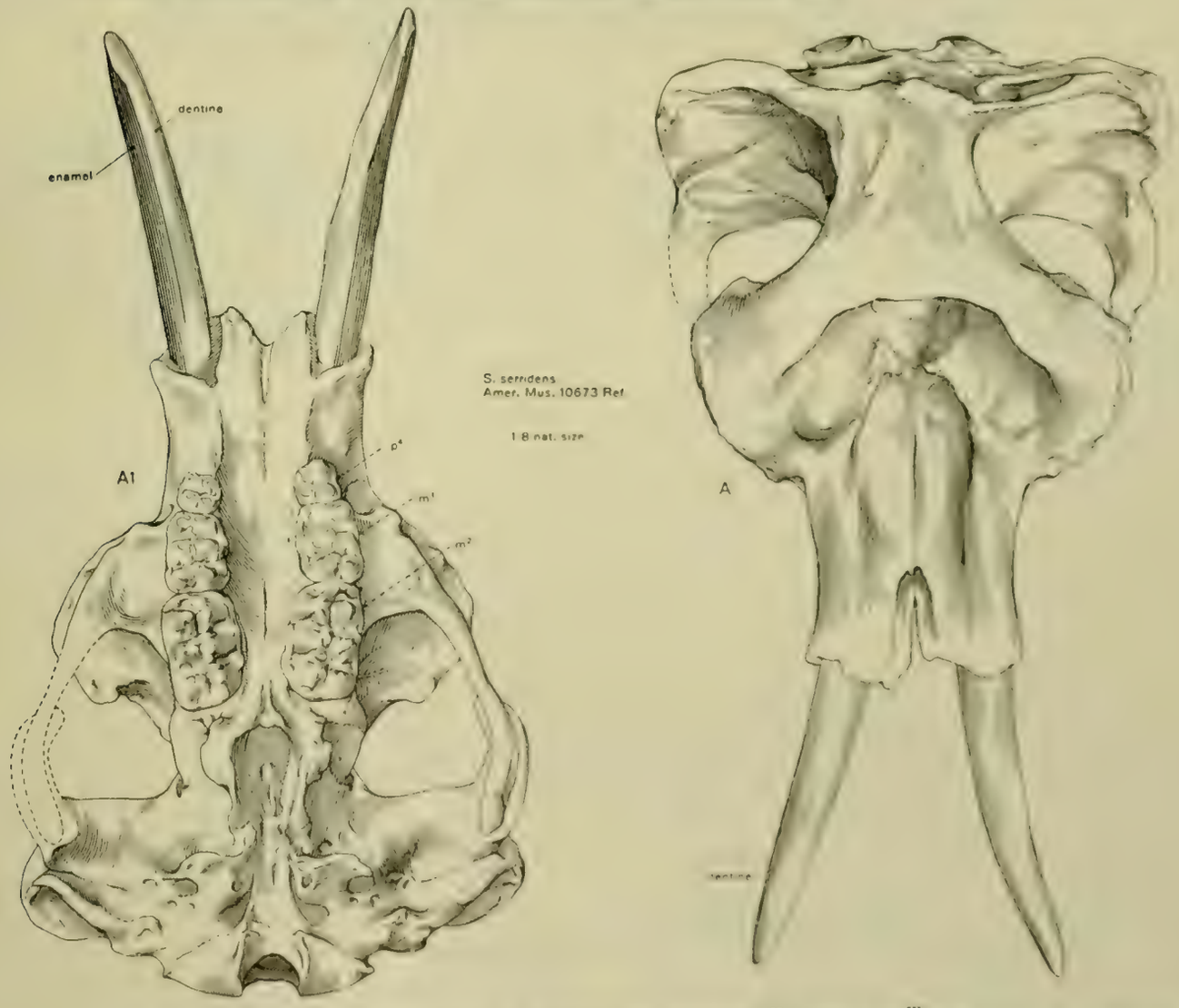
Type: Santa Fé marls A of New Mexico, Upper Miocene (type locality).

Referred: Clarendon formation of Texas, Lower Pliocene (locality of referred skull). See also Frick Coll. (pp. 407, 408), and observations of Frick and Simpson (p. 440 below).

The Santa Fé marls A of New Mexico yielded Cope's type of *Mastodon* [=*Serridentinus*] *productus*, 1875, from levels which are

SERRIDENTINUS PRODUCTUS. MIDDLE-AGED MALE

Fig. 365. Model of *Serridentinus productus*, Upper Miocene of New Mexico and Lower Pliocene of Texas (Clarendon), after skeleton (Fig. 371), one fifty-fifth natural size. Margret Flinsch, 1928.

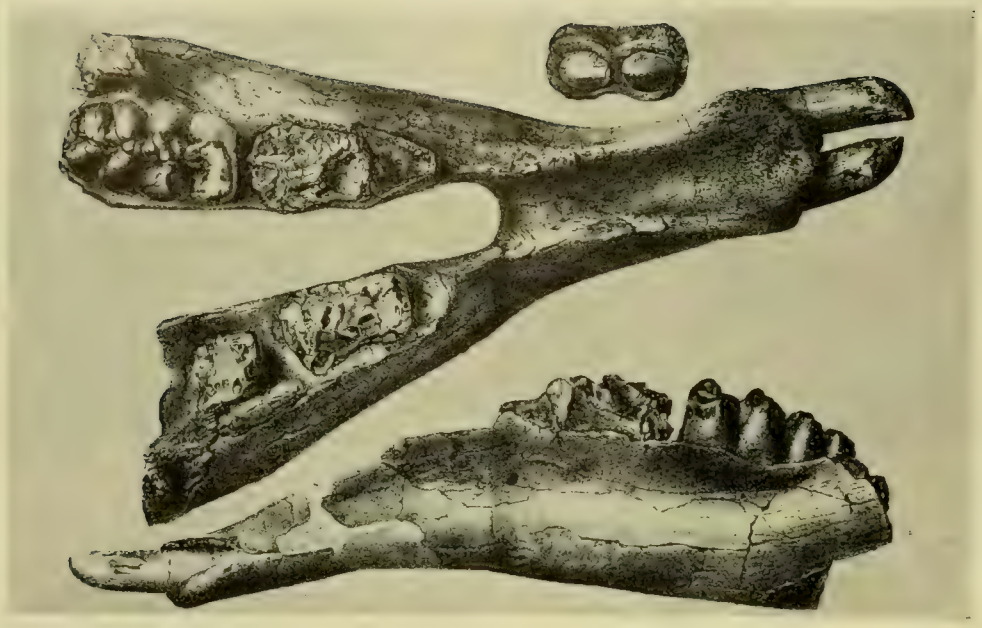


YOUNG ADULT SKULL OF SERRIDENTINUS SERRIDENS, CLARENDON OF TEXAS

Fig. 366. Palatal and superior views of young adult skull of *Serridentinus serridens* n.s. (Amer. Mus. 10673); same skull as shown in figures 364 and 387. One-eighth natural size. Observe the fourth superior premolar, P^4, in this figure and in figure 388, also see figures 362 and 363 for comparison with that of Cope's type of *S. proaeus*.

A1, Palatal view broadened by crushing; the grinders in place are probably P^4 (bilophodont), M^1 (trilophodont), M^2 (trilophodont). The unworn M^2 exhibits the serrate internal trefoils so conspicuous in Cope's unworn type of "*M.*" *serridens* (Fig. 342).

A, Superior view of same cranium.



TYPE OF SERRIDENTINUS PRODUCTUS

Fig. 367. Adult type of *Mastodon productus* Cope, 1875, one-sixth natural size. After Cope, 1877.1, Pl. LXX, figs. 1–3. Nat. Mus. 2346; cast Amer. Mus. 14383. From Santa Fé marls A (?) (lower levels), Upper Miocene, New Mexico.

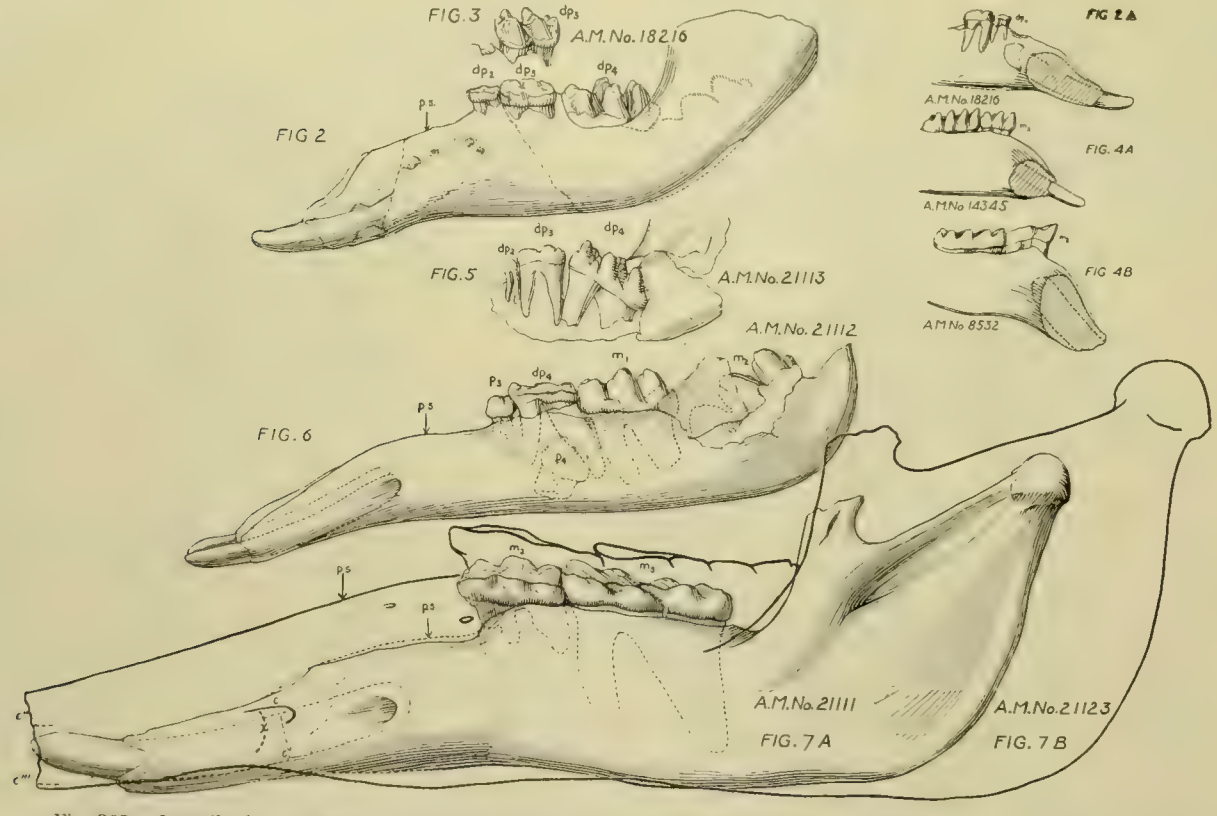
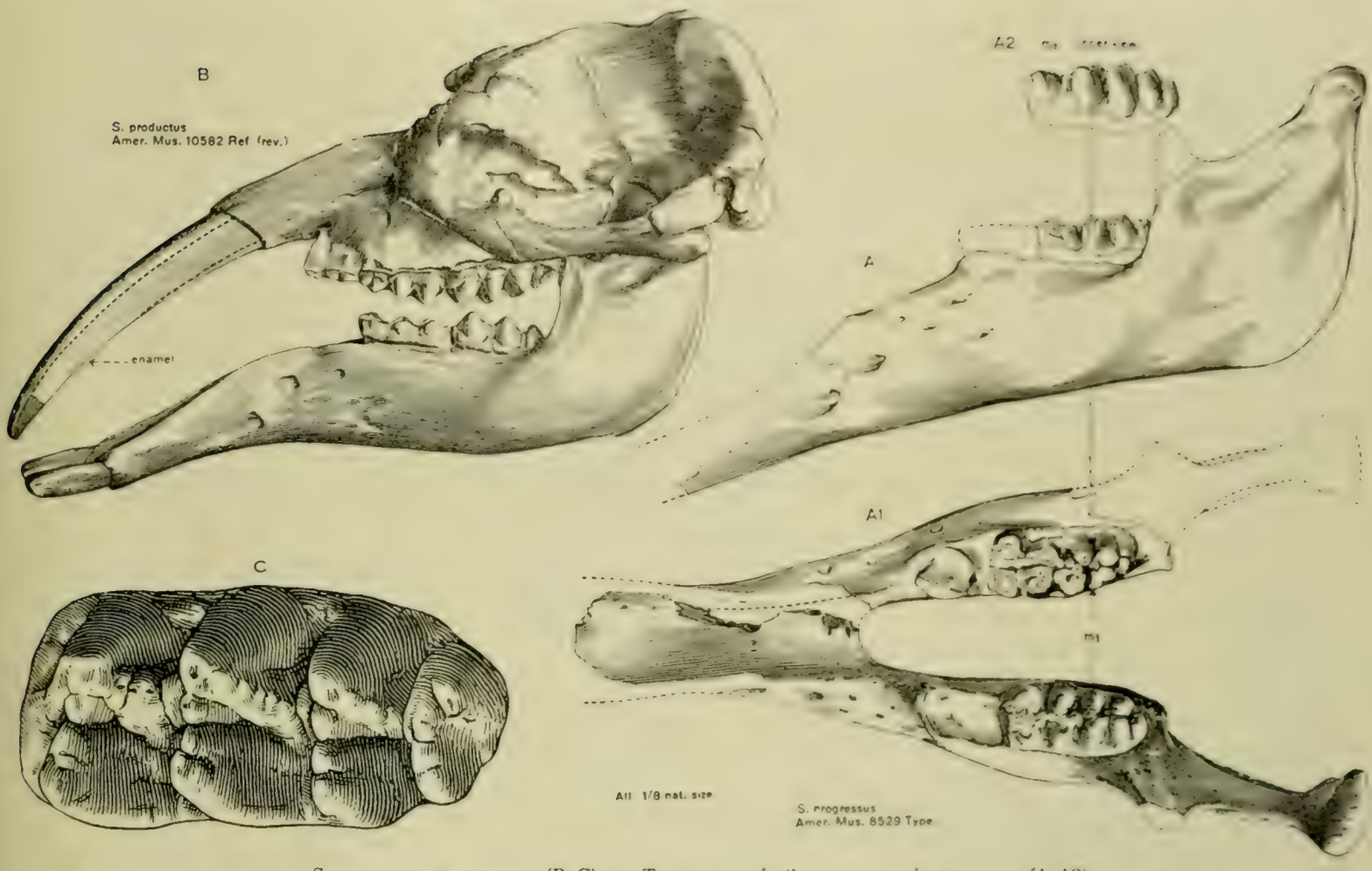


Fig. 368. Juvenile (Amer. Mus. 21112) and adult jaws of *Serridentinus productus* (Amer. Mus. 21111, neotype, and 21113, referred) in comparison with adult jaw of *Trilophodon pojoaquensis* [=*Ocalientinus ojocaliensis*] (Amer. Mus. 21123), all from the Santa Fé marls, New Mexico, Frick Coll., 1925. After Frick, 1926, p. 128. Observe (as in Fig. 372) that *Serridentinus productus* is greatly inferior in size to the contemporary *O. ojocaliensis*. For full references see explanation of figure 174 in Chapter VIII.



SERRIDENTINUS PRODUCTUS (B, C) AND TRILOPHODON [=SERRIDENTINUS] PROGRESSUS (A–A2)

Fig. 369. Comparison of adult skull of *Serridentinus productus* (B) and lower jaws and teeth of *Serridentinus progressus* (A–A2). One-eighth natural size. The greatly elongated rostrum of A, A1 is wanting.

B, Adult skull of *S. productus* (Amer. Mus. 10582) reversed in drawing: the same skull as that shown in the mounted skeleton (Figs. 371 and 372). Observe that three grinding teeth, M^{1-3}, are in use above; that M_1 has dropped out of place; that M^3-M_3 are relatively short and broad.

C, Referred right third inferior molar, r.M_3, of *Serridentinus productus* (Amer. Mus. 10582), enlarged from figure 349 A1.

A, Type jaw and teeth of *Serridentinus progressus* (Amer. Mus. Cope Coll. 8529), left lateral view, external aspect of M_3; A2, inner aspect of same tetralophodont tooth (four and a half crests); A1, superior view of same.

Central conules in all the four and a half crested teeth of *Trilophodon* arise from the center of the valleys and connect only with the outer lobes of the inferior molars. Observe in *Serridentinus* (a) *absence* of 'central conules,' (b) reduction of median conelets, and (c) presence of *trefoil spurs from ectoconelets*.

probably of Upper Miocene age; a nearly perfect referred specimen from Clarendon A, lower levels of Texas, amplifies our knowledge of this species, which is clearly distinguishable (Fig. 350, D1) from *Trilophodon obscurus* (Fig. 350, C1) of the Middle Miocene of Maryland, also from the geologically more recent *S. serridens* (Figs. 387–390) in which the molar ridge-crests are much sharper and more elevated. Since *S. productus* is the most fully known in skull, teeth, and skeleton of all the species of *Serridentinus*, it deserves a complete description in this Memoir.

HISTORY.—This is the animal originally described by Cope in 1875 as *Mastodon productus* from the type, a lower jaw (Fig. 367) from the Santa Fé marls, Upper Miocene, New Mexico, and which he described more fully in 1877 as "*Mastodon*, sect. *Trilophodon*, Falconer." Subsequently the skull and jaws of a similar animal were described and figured by Osborn (1910.346, p. 299, fig. 149) as *Trilophodon productus;* they are now referred to *Serridentinus productus*, and are so figured in the present Memoir.

FRICK, 1926 (FIGS. 174, 368 OF THE PRESENT MEMOIR).—A most welcome recent discovery in the Santa Fé marls was that by the Childs Frick Expedition of 1925, which secured three additional specimens referable to *Serridentinus productus*, as follows:

Adult neotype jaw (Amer. Mus. 21111), Frick Coll.

Juvenile referred left ramus (Amer. Mus. 21112), Frick Coll.

Juvenile referred jaw and milk teeth (Amer. Mus. 21113), Frick Coll.

These neotype and referred specimens are shown in figure 174 (after Frick, 1926) in comparison with the adult jaw of *Ocalicntinus ojocaliensis*. This new comparison confirms the profound differences in size and proportion which existed between nearly contemporaneous species in the two genera *Serridentinus* and *Ocalien-*

tinus occupying an approximately similar habitat. The reader is referred to Frick's complete description of these specimens (Frick, 1926, pp. 142–160).

Materials.—This animal is now among the best known. (1) The type of this species is an adult jaw (Fig. 367) in the United States National Museum (Nat. Mus. 2346), cast (Amer. Mus. 14383), of the Upper Miocene Santa Fé marls of New Mexico. In this specimen the two posterior molars, M_2, M_3, are fully functional. (2) The species is also finely represented by the skull and jaws of an adult individual (Amer. Mus. 10582) secured in the year 1899 by J. W. Gidley in the Clarendon beds, Lower Pliocene of Texas, for the American Museum collection, in which the three superior grinders are present, namely, M 1-3 (see Figs. 349, 370). With this skull were associated many parts of the skeleton, as mounted in the American Museum (Fig. 371). This skull is of middle age, because the functioning teeth are M^1, M^2-M_2, the third posterior molars not yet having come into wear.

Cope's original descriptions and references may be cited in general as follows:

Mastodon productus Cope, 1875. "On a New Mastodon and Rodent." Proc. Acad. Nat. Sci. Phila., Vol. XXVI, 1874 [1875], pp. 221, 222. Type.—Nearly complete lower jaw containing tusks and second and third inferior molars, M_2, M_3, of each side, Nat. Mus. 2346; cast Amer. Mus. 14383. Type Figure.—Rept. U. S. Geog. Surv. W. 100th Mer., 1877, Vol. IV, Pt. II, p. 306, Pls. LXX, figs. 1–3, LXXI, fig. 3, M_3 from the inner side. Type Locality.—Santa Fé marls, New Mexico, approximately of the same age as the Clarendon beds (lower levels) of Texas (Upper Miocene transition to Lower Pliocene). Neotype.—(Cf. Frick, 1926, p. 160) An adult mandible containing M_2, M_3, and tusks of both sides, from the Santa Fé marls, New Mexico, Amer. Mus. 21111, Frick Coll. Compare also Frick, 1926, fig. 7A, p. 128—figures 174 and 368 of the present Memoir.

Type Description.—(Cope, *op. cit.*, 1875.1, p. 222): "The posterior inferior molar supports five transverse series of tubercles, of which the posterior is less developed than the others. Each series is composed of two cusps of a conic form which are separated deeply from each other, and are not united at the base so as to become confluent on attrition. The cones of the outer side support one or two accessory tubercles on a line with their inner or median face, so that the transverse section of a worn tooth with the two accessory cusps is that of a trefoil with the lobes inwards. The penultimate molar in the same jaw supports three transverse series. The symphysis is elongate depressed and subspatulate; its proximal half is excavated, the distal half flattened. Two tusks project from the extremity; they are short, obtuse, and flattened on the inner side. Total length of a specimen which is entire from the end of the symphyseal tusks to just behind the last molar, 29 inches; length to first molar (penultimate), 19 inches; length of first molar, 4.25 inches; of last molar, 6.5 inches; width of same, 3 inches. Width across the rami at end of last molar, 18 inches; do. between anterior borders of first molar, 2.5; do. of symphyseal spout, least, 4.5 inches; at base tusks, 4.75 inches. Length of free portion of symphyseal tusks, 4 inches; diameter of do. 1.75 inches."

In Cope's fuller description, 1877.1, p. 306, he refers to the animal as "*Mastodon*, sect. *Trilophodon*, Falconer"; he describes certain referred specimens also found in the Santa Fé marls near San Ildefonso, New Mexico.

DETAILED DESCRIPTION OF ADULT DENTITION, SKULL, AND SKELETON REFERRED TO SERRIDENTINUS PRODUCTUS (CHIEFLY AMER. MUS. 10582). SEE FIGURES 349, 369, 370

The finely preserved adult skull and jaws (Amer. Mus. 10582), found in the Clarendon in 1899 by J. W. Gidley, shows the true cranial characters and proportions of an animal in a more advanced stage of wear of the incisor tusks and with a full series of superior grinding teeth or true molars, $M^{1\text{-}3}$, in use at the same time. It differs from the young adult skull of *Serridentinus serridens* described below in having lost the fourth superior and inferior premolar teeth and in having substituted the third superior and inferior molars, as illustrated in the beautiful series of drawings by Mrs. Sterling reproduced in figures 369 and 370 in which all the homologous parts are carefully indicated by abbreviations.

Adult Grinding Teeth (Fig. 349).—The detailed structure of the adult grinding teeth of *S. productus* is shown in figure 349 in which the teeth belonging to this same adult skull (Amer. Mus. 10582) are described; we observe that the third superior molars are three and a third crested, that is, just passing out of the trilophodont into the tetralophodont stage; the third inferior molars are four and a fifth crested, that is, the tetartolophid is still relatively low and narrow and the pentalophid is represented by two mamillary cones.

Although recorded from the Clarendon beds, Lower Pliocene of Texas, this referred adult skull shows palatal characters more primitive and quite distinct from those of the younger skull referred to *Serridentinus serridens*. Consequently we may regard it as in a more primitive stage of evolution.

The Superior Teeth.—The superior tusks diverge slightly and curve downward and outward, the left tusk being shorter (330 mm.) than the right (405 mm.), owing to the rate of wear; the enamel band, 41 mm. in width at the entrance of the left tusk at the alveolus, contracts to 17 mm. near the tip. The face of the band is directed outward, and toward the tip slightly downward. The mode of wear of both tusks toward the tip shows that the enamel still serves a distinct purpose since it protects the internal side of the tusks from the too rapid wearing action of the lower tusks, and the external side from the wearing action of the branches of trees upon which these animals probably fed. The tusk is not round but laterally compressed, the vertical diameter at the base, 67 mm., exceeding the transverse diameter, 57 mm., by 10 millimeters.

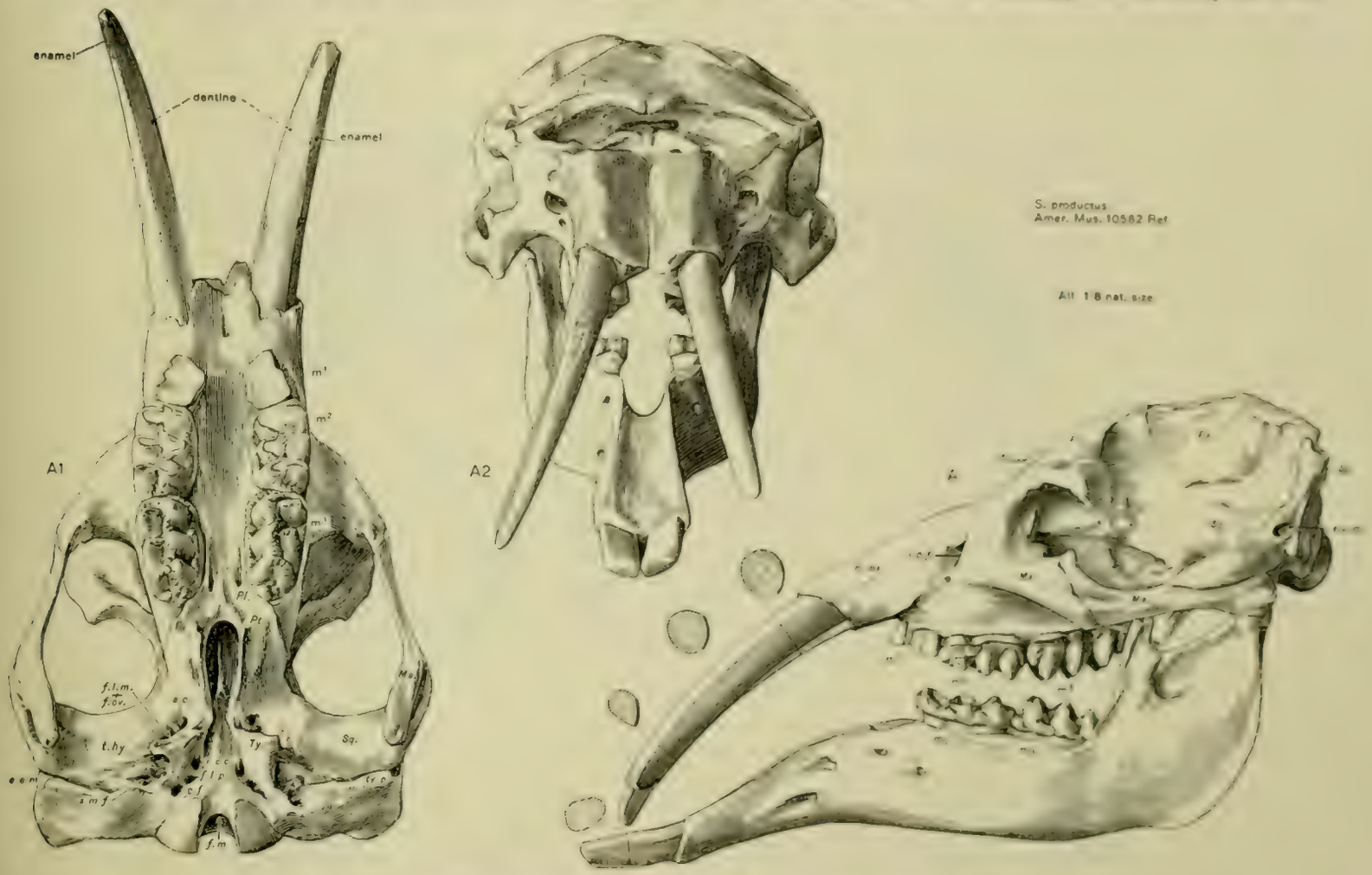
Molars.—The diastema between the tusk and M^1 is 57 mm. This first molar tooth, which while well worn is still in use on both sides, is much the shortest of the molars, the longitudinal diameter being 70 mm. as compared with the transverse diameter 55 mm.; trilophodont. The second superior molar, M^2, beautifully preserved on both sides, is considerably longer (119 mm.) than broad (80 mm.); distinctive characters are the well-developed internal trefoils and the internal cingulum, more or less crenulate and mamillate, which extends back as far as the antero-internal border of the third crest; a rudimentary external cingulum only is developed in the valley between the first and second crests; a rudimentary bimamillate fourth crest is observed at the posterior base of the third crest.

The third superior molar, M^3, gives a beautiful picture of the absolutely unworn crown; in length, 142 mm., it exceeds the width (85 mm.) by 57 mm. The summits of the external cones bear three mamillate cusps each; the trefoil spur of the internal cone of the first crest extends well around the anterior portion of the external cone to the outer side of the crown; the trefoils of the second and third internal cones are irregularly mamillate; the rudimentary fourth crest, consisting mainly of three mamillate cusps, is still low and basal in character, although more pronounced than in M^2; the internal cingulum, as in the second molar, is strongly developed around the antero-internal portion of the crown as far back as the third crest, but not embracing it. A rudiment of the external cingulum is seen only between the first and second crests.

The molars as a whole are close together and parallel, M^3 being separated by 54 mm. and M^1 by 40 mm.

The Inferior Teeth.—The inferior *incisors* are vertically compressed (40 mm.), transversely expanded (53 mm.), short (112 mm.), entirely devoid of enamel and almost in contact in the median line.

The *inferior* molars are readily distinguished from the superior by (1) their narrower crowns, which appear to be chiefly due to the absence of basal cingulum except in the external valleys between the crests; the anterior lobe of M_3 (73 mm.) is, however, slightly narrower than the anterior lobe of M^3 (76 mm.); the cingulum adds 9 mm. to the width of the superior molars. (2) In pattern the lower molars reverse the upper, that is, the trefoils are upon the outer cones, and such rudiments of the cingulum as exist between the valleys are found on the *outer* sides of the teeth, whereas in the



Adult Skull and Jaws Referred to Serridentinus productus

Compare skeleton (Fig. 371), model (Fig. 365), restoration (Fig. 341).

Fig. 370. Skull and jaws of adult *Serridentinus productus* (Amer. Mus. 10582), Clarendon beds, Lower Pliocene of Texas. One-eighth natural size.

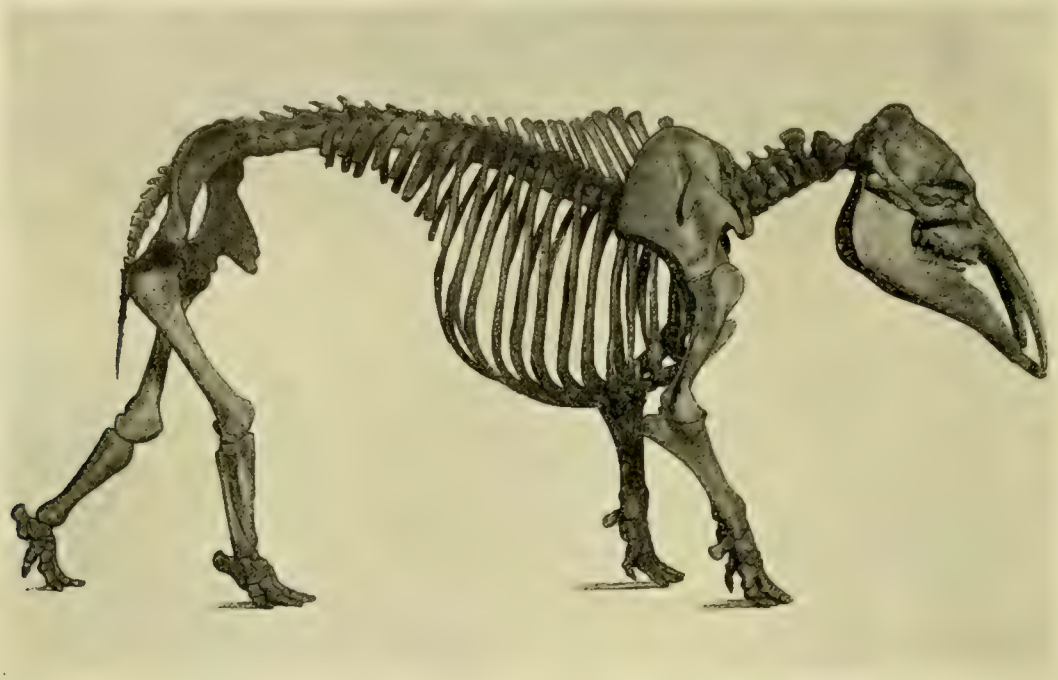
Observe: (1) That the trilophodont M^1 is much worn and that the corresponding tooth in the lower jaw, M_1, has dropped out of place; (2) that the trilophodont M^2 is half worn and that the trefoils in this stage of wear resemble those of the typical *Trilophodon;* (3) that in the unworn third superior, M^3, and inferior, M_3, molars the serrate condition of the internal lobes is similar to that in the type, M^3, of *serridens;* M^3, fully obtruded, is feebly tetralophodont, having only three and a third crests.

A1, palatal view; A2, anterior view; A, left lateral view. Figure 369B shows the left lateral view of the same skull (Amer. Mus. 10582). This skull is mounted (Fig. 371) with the reconstructed skeleton (chiefly Amer. Mus. 10582).

upper molars both the cingulum and the trefoils are upon the *inner* sides. (3) A third distinction of the lower molars is seen in the fact that the internal cones, as well shown in M_3, each have two large, mamillate cusps instead of the three small mamillate cusps in the upper molars. (4) A fourth character, which may be an individual variation, is that M_1 is already shed while M^1 is retained, and (5) a fifth is that M^2 is broadest anteriorly while M_2 is broadest posteriorly. (6) A sixth and much more striking distinction is the fact that M_3 is practically tetralophodont, the fourth crest being no longer basal in character; this accords with the more forward position of the lower grinders and consequent elongation of the posterior portion of M_3 in the ungulates generally. (7) A seventh character is the rudimentary pentaloph indicated by two mamillary cones, as in M^2-M_2, not observed in the partly fractured type M^2 of *Serridentinus serridens*. (8) These two cones of the pentaloph and pentalophid are more strongly developed in *Ocalientinus* (*Ser.*) *floridanus*.

Second Inferior Molar.—More in detail, M_2 in its broadest part opposite the third crest measures 75 mm., which is exactly the same as the corresponding measurement of M_3, but M_3 is broadest anteriorly, measuring 76 mm. The anterior trefoils are almost confluent; the external cingulum is somewhat more progressive in the right M_2 than in the left, and the rudimentary fourth crest (tetartolophid) consists mainly of two basal mamillate cusps, it is, in fact, more clearly defined than the crenulate basal ridge of M^2.

Third Inferior Molar.—Unlike M_2 this crown is nearly uniform in breadth, 75–76 mm.; the fourth crest, however, is somewhat lower and narrower, and its trefoil is less distinctly evolved, the approximate longitudinal measurement being 163 mm. The trefoils are not only developed on the slopes of the external cones, but rudiments of these important folds appear at the very bases of certain of the internal cones, prophetic of the double-trefoiled condition.



Adult Skull and Restored Skeleton of Serridentinus productus
Compare Model (Fig. 365)

Fig. 371. Skeleton referred to *Serridentinus productus* (chiefly Amer. Mus. 10582), from the Clarendon beds, Lower Pliocene of Texas. Collected by J. W. Gidley, Amer. Mus. Expedition of 1899. Mounted by Charles Lang, 1921. One twenty-fourth natural size.

This skeleton is reconstructed from a single individual, the missing parts restored in plaster (see key, Fig. 372). The original skull and jaws are mounted with the skeleton. Thirteen vertebræ, most of the ribs, pelvis and sacrum, the right hindlimb bones with the exception of the foot and some of the tarsals are original bone. The rest of the vertebræ, a few ribs, the left hindlimb (excepting the foot) and both forelimbs are modeled in plaster. The feet are all restored excepting the left hind pes. The form and proportions of the restored parts are studied from various remains of different species of *Trilophodon*, supplemented in part by comparisons with the American Mastodon and modern elephants.

The articulation and pose of the skeleton are based upon photographs and observations of the elephant; the pose is a phase of the walking step. The original and restored portions are clearly shown in figure 372.

Inferior Maxilla.—The jaw is elongate (905 mm.) from the angle to the end of the symphysis, shallow (125 mm.) below the interval between the two molars, moderately stout (120 mm.) opposite M_3, with elongate, narrow symphysis (300 mm.), slightly constricted (118 mm.) in the mid-portion; the angle inclines forward, the condyles are transversely oval (115 mm. transverse, 60 mm. anteroposterior); the coronoid is sessile and considerably

MEASUREMENTS AND INDICES OF SERRIDENTINUS (OCALIENTINUS) FLORIDANUS,[1] S. PRODUCTUS, S. SERRIDENS

INFERIOR MOLARS	P_4 ap.	P_4 tr.	P_4 I.	M_1 ap.	M_1 tr.	M_1 I.	M_2 ap.	M_2 tr.	M_2 I.	M_3 ap.	M_3 tr.	M_3 I.	M1–M3 ap.
Serridentinus [=*Ocalientinus*] *floridanus*													
Leidy's type M_3 (Nat. Mus. 3083)										226	85	38	
M_2, metatype							127	80	63				
Serridentinus serridens													
Referred (Amer. Mus. 10673)	57	43	75	92	62	67	139	69	50				
Length of $l.P_4$-M_2													290
Serridentinus productus													
Cope's type (Nat. Mus. 2346, cast Amer. Mus. 14383)							123	76	62	164	76	46	
Serridentinus productus													
Referred (Amer. Mus. 10582), with skull							124e	75	60e	163	76	47	
Length of $l.M_{2\text{-}3}$													275
SUPERIOR MOLARS	P^4 ap.	P^4 tr.	P^4 I.	M^1 ap.	M^1 tr.	M^1 I.	M^2 ap.	M^2 tr.	M^2 I.	M^3 ap.	M^3 tr.	M^3 I.	
Serridentinus [=*Ocalientinus*] *floridanus*													
Metatypes				97e	66.6e	69e	125e	80e	64e	210	107	51	
Length of $M^{1\text{-}3}$													420e
Serridentinus serridens													
Cope's type (Amer. Mus. 14297)							130	80	61				
Serridentinus serridens													
Referred (Amer. Mus. 10673)	60	50	83	94	73e	78e	137e	90	66e				
Length of $l.P^4$-M^2													285
Serridentinus productus													
Referred (Amer. Mus. 10582), with jaw				70	55	79	119	80	67	142	85	60	
Length of $l.M^{1\text{-}3}$													325

below the level of the condyle. There are from three (right side) to four (left side) foramina on the outer face of the anterior half of the jaw. The symphysis is troughed superiorly and flat inferiorly.

ADULT SKULL

PALATAL VIEW.—The distance from the condyles to the incisive border (770 mm.) exceeds the greatest diameter across the zygomata (550 mm.) by 220 mm. The palatal union of the maxillaries and palatines extends the hard palate (470 mm.) well backward, so that the posterior nares open somewhat behind the posterior molars. The groove separating the pterygoid plate of the alisphenoid from the maxillaries is clearly defined; but the pterygoid limits cannot be made out, the sutures having completely closed; in the interpterygoid space is a deep vomerine keel. The foramina occupy a compressed area.

On the inner side the tympanics project downward on an acutely triangular process, on the inner side of which lies the carotid canal, precisely as in *Elephas*, while posterior to this tympanic process is the foramen lacerum posterius, there being no foramen condylare.

FORAMINA.—Even in this early form the general arrangement and relations of the elements and foramina of the posterior basal aspect of the skull is strongly suggestive of that in *Mastodon* and *Elephas*. The alisphenoid canal is very far back of the foramen ovale and has apparently become confluent with the foramen lacerum medius, the carotid canal pierces the inner side of the trihedral bulla, the foramen lacerum posterius is about where one might look for a foramen condylare. Also there is the same prominent oblique ridge running down from the postorbital process of the frontal to the anterior outer end of the pterygoid wing of the ali-

[1]Referred (1934) to *Ocalientinus* Frick.

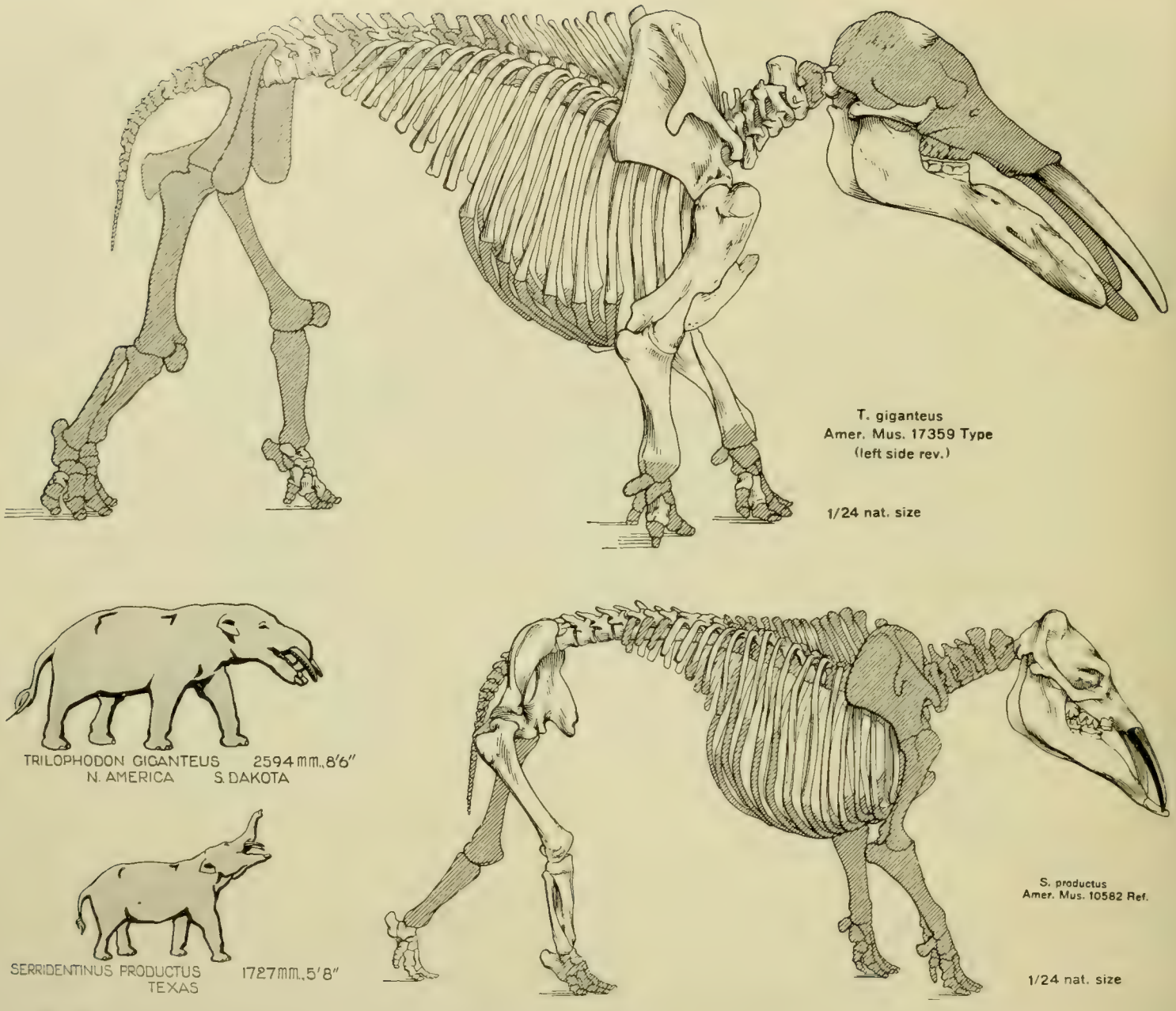


Fig. 372. Comparative restorations of the skeleton of *Trilophodon giganteus* type and that of *Serridentinus productus* ref.; both about one twenty-fourth natural size.

Adult Skeleton of Trilophodon

(Upper) Trilophodon. Restored skeleton of *T. giganteus* Osborn (Amer. Mus. 17359) reversed in the drawing to show comparison with *Serridentinus*. Obliquely shaded portions are restored, namely, upper portion of skull and teeth, right upper and both lower tusks, atlas, spines and centra of seven thoracic and lumbar vertebræ, caudals, entire pelvis, and hindlimbs. The original material (outline partly shaded) includes the left upper tusk (here reversed), part of the summit of the cranium, left zygomatic arch, occipital condyles, entire lower jaw, cervical 2 to dorsal 12 inclusive, also dorsals 17 and 19, 3 lumbars, 2 caudals, nearly complete forelimbs, and scattered digits of manus and pes; complete sternum. The history of the *T. giganteus* skeleton is also fully described in the *Trilophodon* section above (Chap. VIII).

Adult Skeleton of Serridentinus

(Lower) Serridentinus. Restored skeleton of *S. productus* (Amer. Mus. 10582). The history of this skeleton is to be found in the legend of figure 371 above. Compare skull of *Serridentinus productus*, figure 370 above, and dentition, figure 349 A, A1, above.

Outline Restorations of Serridentinus (lower) and Trilophodon (Upper)

Inset.—Drawn from the above skeletons to a uniform one-hundredth scale. The marked disparity in size of *Serridentinus productus* (lower) appears to be characteristic of the Serridentinæ in general, in comparison with the larger and much more massive 'oblique-tuskers' of the Longirostrinæ, such as *Trilophodon giganteus* (upper).

sphenoid; the squamosal, lacking a postglenoid ridge, completely closes over the external auditory meatus below. All this goes to show that the proboscideans very early acquired this shortening up of the back of the cranium inferiorly, so widely different from the elongate posterior palatal region of the condylarths.

MEASUREMENTS OF SERRIDENTINUS PRODUCTUS (AMER. MUS. 10582) AND OF S. SUBTAPIROIDEUS (CAST AMER. MUS. 2572)

	Serridentinus productus	*Serridentinus subtapiroideus*
Height of protoloph, M^3 (external)	35	43
Height of metaloph, M^3 (external)	38	47+
Height of tritoloph, M^3 (external)	34	40
Height of tetartoloph M^3	14e	30

	Serridentinus productus						
TEETH	M^1	M^2	M^3	M_2	M_3	M^1-M^3	M_2-M_3
Anteroposterior	70	119	142	124e	163		
Transverse	55	80	85	75	76		
Index	79	67	60	60e	47		
Length						325	275
SKULL							
Occipital condyle to tip of right tusk						1068	
Occipital condyle to tip of premaxilla						800	
Breadth across squamosals						499 dist.	
Breadth across jugals						545	
Breadth across M^2						225	
Breadth across M^3						225	
JAWS							
Articular condyle to tip of tusks						1010	
Articular condyle to tip of jaw						905	
Posterior border to tip of tusks						950	
Posterior border to tip of jaw						845	
Breadth across both rami						410	
Breadth across M_2						211	
Breadth across M_3						237e	
Anterior end of M_2 to tip of tusk						506	
Anterior end of M_2 to tip of jaw						401	

COMPARISON OF RECONSTRUCTED SKULLS AND SKELETONS OF SERRIDENTINUS AND TRILOPHODON

The accompanying diagram (Fig. 372) shows in oblique lines the *restored* portions of the adult mounted skeleton of *Serridentinus productus* (Amer. Mus. 10582) belonging with the skull of the adult *S. productus* above described; it is a key to the photograph of the same skeleton (Fig. 371) above. It shows that the only complete parts of the reconstructed skeleton are the skull, a number of the thoracic ribs, the centra of the posterior thoracic and lumbar vertebræ, the pelvis, the right hindlimb as far as the astragalus, and the left hindfoot nearly complete. This restoration is so far conjectural that it gives only an approximate idea of what the complete skeleton of *Serridentinus productus* was like. We may discover that the restored shaded portions, especially of the scapula and forelimb, do not correspond with the reality. The animal here is reduced to one twenty-fourth natural size, and considering that it is of Lower Pliocene age, we conclude that the Upper Miocene species of *Serridentinus* were probably smaller and less massive than the Upper Miocene species of *Trilophodon*.

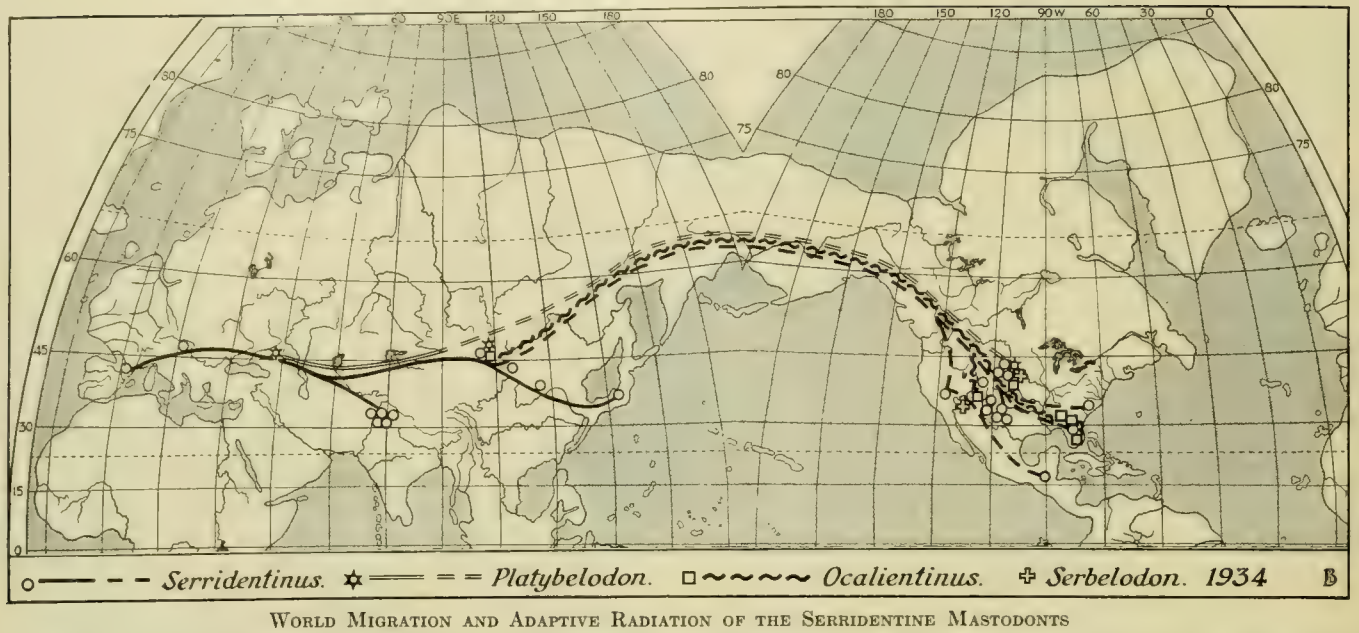
Comparing the skeleton (lower figure) of *Serridentinus* (Amer. Mus. 10582) with that (upper figure) of *Trilophodon* (Amer. Mus. 17359), we observe that it is greatly inferior in size; the jaw is medilongirostral, while that of *Trilophodon* is hyperlongirostral. In the *S. productus* tusks the enamel occupies the typical position on the outer inferior part of the superior incisors; in *Trilophodon giganteus* the enamel lies directly along the lower border of the tusks.

It is obvious that these two restored skeletons do not enable us to institute a real comparison between *Serridentinus* and *Trilophodon*, for the reason that the missing parts in *Serridentinus* (lower figure) are the very parts which are present in *Trilophodon* (upper figure), e.g., the forelimbs. Conversely the parts which are present in *Serridentinus*, e.g., the hindlimb and complete skull, are wanting in *Trilophodon*. The neck, wanting in *Serridentinus*, is present in *Trilophodon*. The lower jaws alone are present in both specimens. It is very important to observe that the lower jaw of the hyperlongirostral *Trilophodon* is capable of reaching the ground and of assisting in feeding, and that there are only *two* grinding teeth in use at one time; whereas the shorter lower jaw in *Serridentinus* cannot so readily reach the ground, and there are *three* grinding teeth in use at the same time. This important difference between the dental mechanism in *Trilophodon* and the Serridentinæ seems to be a constant feature, because in the species *Ocalientinus* (*Ser.*) *floridanus*, described below, there are apparently three grinders in use at once.

COMPARISON OF THE JAWS AND GRINDERS.—A comparison of the jaws characteristic of members of these two genera is facilitated by the detailed drawings of *Serridentinus productus* and *Trilophodon giganteus* in figure 282. The mandible of *T. giganteus* is greatly elongated and downturned; the mandible of *S. productus* is moderately elongated and horizontal.

We observe that the same contrast in the use of the grinders obtains between *Serridentinus productus* and *Trilophodon giganteus*, namely, that in *T. giganteus* type there are only two lower molars in use and that the last lower molar is relatively long and narrow.

Fig. 372a. PRIMITIVE SERRIDENTINES OF EURASIA AND NORTH AMERICA
RESTORATIONS BY MARGRET FLINSCH, UNDER THE DIRECTION OF HENRY FAIRFIELD OSBORN
ONE-HUNDREDTH NATURAL SIZE



World Migration and Adaptive Radiation of the Serridentine Mastodonts

Fig. 373. The medilongirostral 'Serridentines' or serrate-toothed mastodonts browsed chiefly in forested areas, whereas the hyperlongirostral or long-jawed mastodonts of the genera *Trilophodon*, *Amebelodon*, and *Platybelodon* frequented the river, shallow lake, and pool border areas.

6. PROGRESSIVE FOREST-LOVING SPECIES OF KANSAS, FLORIDA, AND SOUTH AND NORTH CAROLINA

(Osborn, 1934) The reader's attention is called to the transfer of *Serridentinus floridanus, S. republicanus, S. floridanus leidii, S. bifoliatus, S. obliquidens*, and *S. florescens* to the genus *Ocalientinus*, readily distinguished by dominant and florescent trefoil spurs, also by abbreviated cranium and elongate, deeply grooved rostrum **(continued on p. 433, with full description of *Ocalientinus*).**

Ocalientinus (Serridentinus) republicanus Osborn, 1926

Figures 282, 374, 375, 385, 403

Type and paratype: Republican River formation, Lower Pliocene, northwestern Kansas. Referred: Springview, Nebraska, and Long Island, Phillips County, Kansas.

This Pliocene stage of Kansas, the Republican River, occurs in the same beds with Cope's *Tetralophodon campester*. With its roundly blunted cones and conelets, *Ocalientinus* (*Ser.*) *republicanus* belongs in Adaptation A of the Serridentinæ, but it is far more progressive than *Serridentinus productus*; not quite so specialized as the Pliocene *Ocal.* (*Ser*). *floridanus* of Florida (Fig. 385).

Serridentinus republicanus Osborn, 1926. "Additional New Genera and Species of the Mastodontoid Proboscidea." Amer. Mus. Novitates, No. 238, November 30, 1926, p. 6. Type.—A nearly perfect left mandible containing M_{1-3}. Amer. Mus. 8536. Paratype.—Portion of a right mandible with M_2 *in situ*. Amer. Mus. 8530. Type and Paratype Horizon and Locality.—Republican River formation, Lower Pliocene, northwestern Kansas, correlated with Bone Valley = Alachua, Lower Pliocene of Florida.

The type (Fig. 374A) of this species, named *Serridentinus republicanus* after the well-known horizon in which it occurs, is a nearly perfect left mandible (Amer. Mus. 8536) containing M_{1-3}; the paratype from the same horizon (Fig. 374 B) consists of a portion of a right mandible (Amer. Mus. 8530) with M_2 *in situ*. Of the same geologic age is a fine referred mandible of the right side, containing M_{1-3}, an incomplete left ramus, and an inferior molar of the left side, l.M_3 (Amer. Mus. 14438), from Springview,

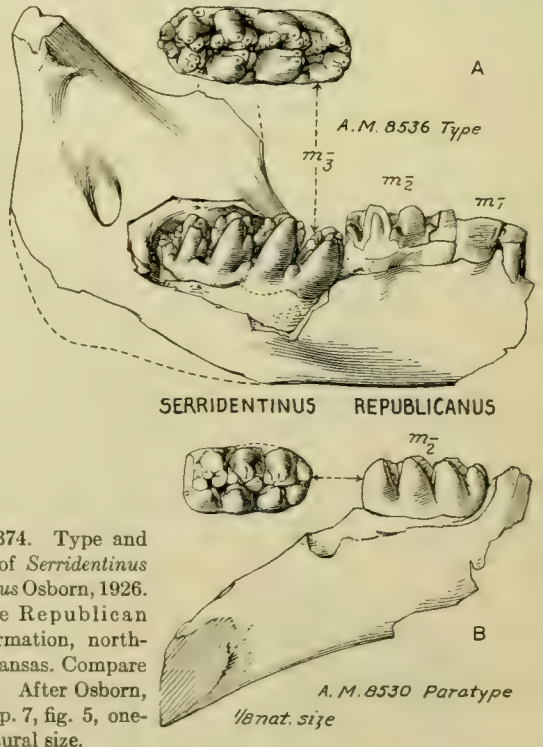
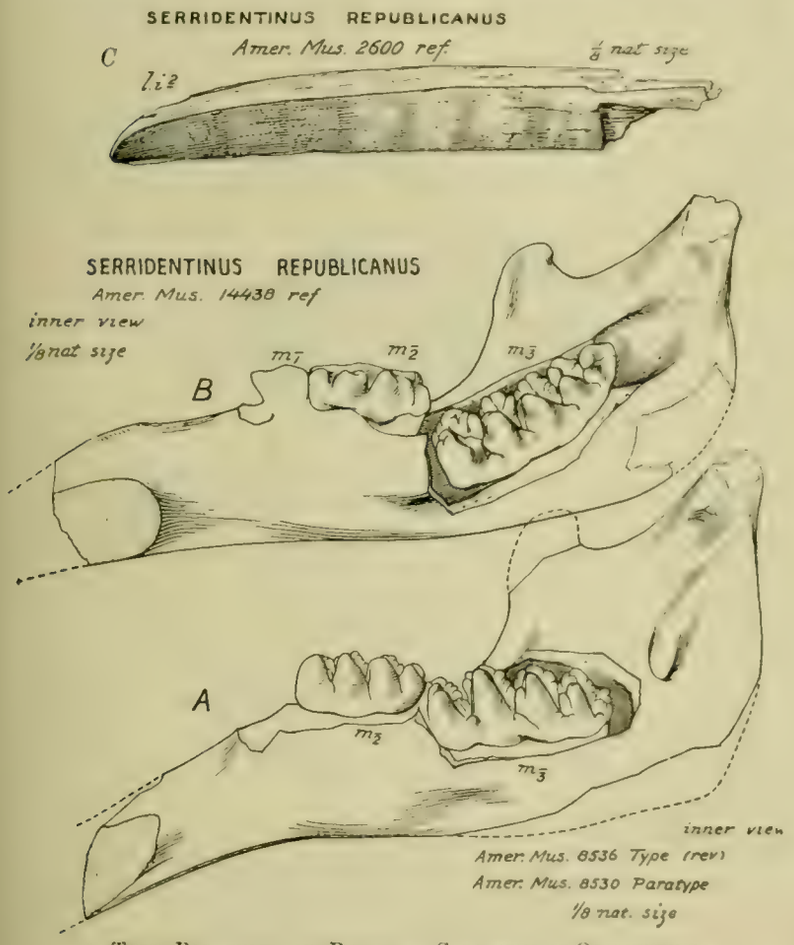


Fig. 374. Type and paratype of *Serridentinus republicanus* Osborn, 1926. From the Republican River formation, northwestern Kansas. Compare figure 375. After Osborn, 1926.706, p. 7, fig. 5, one-eighth natural size.

A, Type mandible (Amer. Mus. 8536) seen on the internal aspect; internal and crown views of third left inferior molar, l.M_3.

B, Paratype mandible (Amer. Mus. 8530); internal and crown views of second right inferior molar, r.M_2.

Nebraska. There is also a left superior tusk, l.I², superbly preserved with its broad enamel band, and a second inferior molar of the left side, l.M₂ (Amer. Mus. 2600), from Long Island, Phillips County, Kansas. These type, paratype, and referred specimens absolutely establish *Serridentinus republicanus* as belonging to a genus and species totally distinct from the classic type of *Tetralophodon campester*, which is recorded from this same geologic horizon, namely, the Republican River of northwestern Kansas.



TYPE, PARATYPE, AND REFERRED SPECIMENS OF OCALIENTINUS (SERRIDENTINUS) REPUBLICANUS

Fig. 375. Type, paratype, and referred dentition of *Serridentinus republicanus*, all figures one-eighth natural size. A, B, after Osborn, 1926.706, p. 8, fig. 6.

A, Composition of type (Amer. Mus. 8536, rev.) and paratype (Amer. Mus. 8530) mandibles, shown in natural position in figure 374.

B, Referred right mandible containing M_{1-3}, internal view (Amer. Mus. 14438).

C, Referred left superior incisive tusk, l.I² (Amer. Mus. 2600).

TYPE AND PARATYPE CHARACTERS (COMPARE OSBORN, OP. CIT., 1926.706, P. 7).—(1) Superior incisors elongate, laterally compressed, with very broad enamel band. (2) First inferior molars functioning until third molars come into place. (3) Second inferior molars with three pairs of rounded prominent internal-external cones and two prominent tetartolophid cones (compare *S. serridens*). (4) Third inferior molars elongate with four prominent internal-external cones, proto-, meta-, trito-, and tetartolophids, the tetartolophid is much inferior in height (elev. 55 mm.) as compared with the metalophid (elev. 87 mm.). (5) Three to five low posterior conelets, representing the pentalophid. (6) Cones and conelets of the rounded, non-compressed form of *S. productus* and of *O.* (*S.*) *floridanus*, rather than of the elevated, compressed form of *S. serridens*. (7) Highly characteristic multiple conelets rising on the external trefoil spurs, with from three to four conelets clustered at the sides and summits, thus exceeding any other florescent trefoil spurs and conelets in the Serridentinæ, excepting *O.* (*S.*) *florescens*. (8) Intermediate columnar conelets rising on anterior faces of internal cones of tritolophid and tetartolophid.

Ocalientinus (Serridentinus) bifoliatus Osborn, 1929

Figure 376

Type and paratype, Brewster, Polk County, Florida. Lower Pliocene, Alachua clays.

The specific name *bifoliatus* refers to the double trefoils shown on the three anterior ridge-crests of the type (Fig. 376), also to the presence of five ridge-crests as in *Ocalientinus* (*Ser.*) *floridanus*.

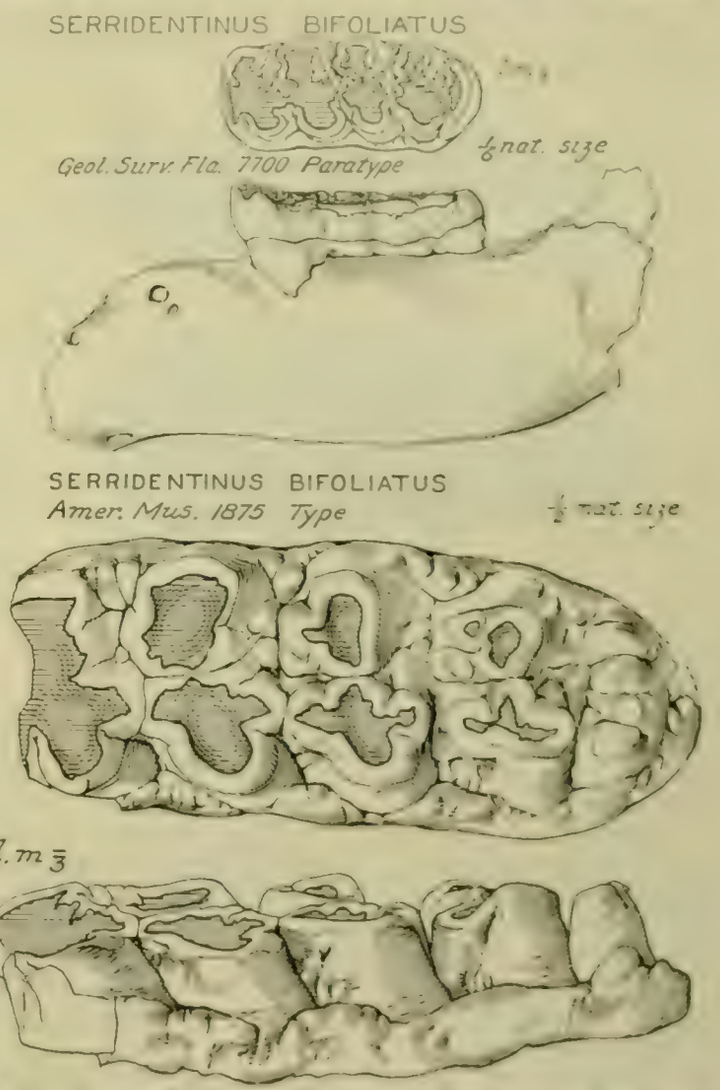


Fig. 376. TYPE AND PARATYPE OF OCALIENTINUS (SERRIDENTINUS) BIFOLIATUS

(Lower) Type third left inferior molar, l.M_3 (Amer. Mus. 1875), crown and external views, one-half natural size.

(Upper) Paratype jaw and third left inferior molar, l.M_3 (Geol. Surv. Fla. 7700), one-sixth natural size. Through courtesy of Director Herman Gunter.

Observe large trefoils and cingulum on external side of crown; rudimentary trefoils and absence of cingulum on convex internal side.

Serridentinus bifoliatus Osborn, 1929. "New Eurasiatic and American Proboscideans," Amer. Mus. Novitates, No. 393, December 24, 1929, p. 2. TYPE.—A third lower molar of the left side, l.M_3 (Amer. Mus. 1875), presented by Professor Raymond. HORIZON AND LOCALITY.—Lower Pliocene. Brewster, Polk County, Florida. PARATYPE.—A left inferior mandibular ramus, with M_3 *in situ*, showing alveolus of small rounded inferior tusks, l.I_2 (Geol. Surv. Fla. 7700), from the mines of the Amalgamated Phosphate Company (American Cyanimid Company), Brewster, Florida. TYPE AND PARATYPE FIGURE.—Type, Osborn, 1929.797, p. 2, fig. 2; type and paratype, figure 376 of the present Memoir.

SPECIFIC CHARACTERS.—The type l.M_3 (Amer. Mus. 1875) was originally identified as *Serridentinus brewsterensis* but was removed owing to the presence of double trefoils on the proto-, meta-, and tritolophids; in the paratype jaw (Geol. Surv. Fla. 7700) there are double trefoils on the proto- to tetartolophids inclusive—hence the name *bifoliatus*. The pentalophid in the type measures 51 mm. in breadth, 45 mm. in height; the pentalophid in the paratype is elevated, broadly transverse. There is a strong external cingulum in both the type and paratype.

TYPE AND ONE OF THE METATYPES OF OCALIENTINUS (SERRIDENTINUS) FLORIDANUS

Fig. 377. Type of *Mastodon* (*Trilophodon*) *floridanus* Leidy, 1886. An M_3 of the right side, from the Alachua clays, Florida. Nat. Mus. 3083; cast Amer. Mus. 17725. After Leidy and Lucas, 1896, Pl. VI, figs. 1 and 2, reduced to one-third natural size. The type and metatypes of the same species are reproduced in figure 379.

The aged paratype lower jaw was doubtfully placed in the genus *Serridentinus*[1] because of its extremely broad, robust proportions (depth below M_3 155 mm., width opposite M_3 136 mm.), differing widely from the more slender jaws of the Pliocene and Miocene species of this genus. The broken rostrum, containing the rounded alveolus of I_2, is somewhat deflected, but it bears evidence of considerable abbreviation as compared with that of *Serridentinus productus*.

The measurements (in millimeters) of the type and paratype grinding teeth are as follows:

	ap.	tr.	I.
Type (Amer. Mus. 1875)	195	81	42
Paratype (Geol. Surv. Fla. 7700)	212	93	44

[1]Transferred (1934) to the new genus *Ocalientinus* Frick.

Ocalientinus (Serridentinus) floridanus Leidy, 1886

Figures 340, 350, 377–380, 403

Lower Pliocene, Alachua clays, Mixson's bone bed, near Williston, Levy County, Florida.

Compare *Ocalientinus* (*Serridentinus*) *floridanus leidii*. See also observations of Frick and of Simpson (p. 440 below).

Serridentinus floridanus[1] is memorable as one of the last fossil mammalian species to be described by the veteran Joseph Leidy. It is one of the final members (Figs. 350 and 377) of Adaptation A, with blunted cones and conelets adapted to the relatively moist and luxuriant foliage of the Lower Pliocene of Florida. As shown in figure 350 it may be a descendant of *S. productus*. This is a very important and abundant Lower Pliocene species characteristic of the southeast coast of the United States, as found in Florida. It is also recorded from northern Mexico (Amer. Mus. 22612).

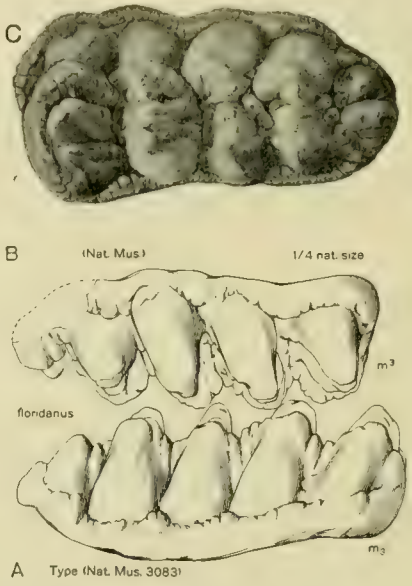


Fig. 378. Type and metatype of *Mastodon* (*Trilophodon*) *floridanus* Leidy; outer aspect. All figures one-fourth natural size.

A, Type, Nat. Mus. 3083 (cast of type Amer. Mus. 17725), M_3, right side.

B, Metatype, Nat. Mus. (cast Amer. Mus. 17726), M^3, right side.

C, Photograph, crown view of metatype, same tooth as B. After Leidy and Lucas, 1896, Pl. VII, fig. 1.

It is a large and progressive animal readily distinguished from the Upper Miocene Serridentines by its large size, hypsodonty, and progressive ridge-crest formula, namely: M $1\frac{3}{3}$, M $2\frac{3}{3}$, M $3\ \frac{4\ 1/3}{5\ 1/4}$; also by deep *serrations* of the trefoil borders. Worn specimens of the upper and lower grinders M^1-M_1, M^2-M_2, may readily be confused with those of *Trilophodon*, but unworn crowns show the Serridentine pattern very distinctly.

The species *Ocalientinus* (*Ser.*) *floridanus* is in a Lower Pliocene stage of evolution and is certainly far more progressive than *Serridentinus productus* which is in a Mio-Pliocene stage. The

following specific characters may now be assigned to this stage, awaiting further knowledge of the structure of the cutting teeth and of the skeleton.

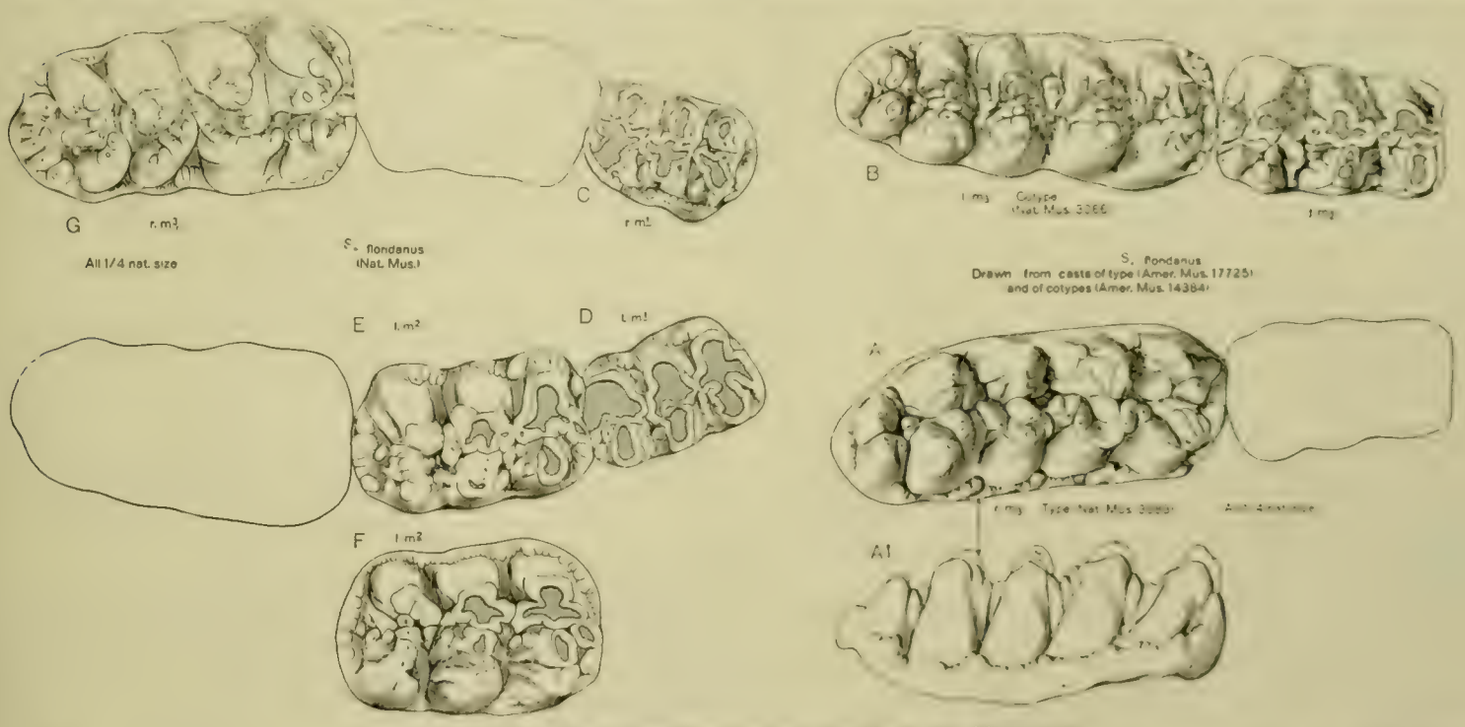
Specific Characters.—(1) Ridge formula: M $1\frac{3}{3}$, M $2\frac{3}{3}$, M3 $\frac{4\,1/3}{5\,1/4}$. (2) Serrate trefoils arising on external lobes of lower molars and on internal lobes of upper molars as serrated ridges, as in the genotypic species *S. serridens*. (3) External and internal cones separated near the summits by a shallow longitudinal fissure, but more or less confluent. (4) Superior lophs consisting of two cones surmounted by quintuple to sextuple conelets; inferior lophs consisting of two cones surmounted by quadruple conelets. (5) Crenulate and chœrodont tendency on the sides of the lobes. (6) In M^2-M_2 a pair of supplementary posterior cones indicating a rudimentary tetartoloph and tetartolophid (as in *S. productus* and *S. serridens*). (7) In M^3-M_3 two or three supplementary posterior cones indicating a rudiment of a pentaloph and hexalophid.

Location of Type and Metatypes

The type and metatypes of this animal, from the Lower Pliocene of Florida, consist of a number of isolated and beautifully preserved upper and lower molar teeth which were described by Leidy in his last contribution to palæontology (Leidy and Lucas, 1896) as typical of the species *Mastodon* (*Trilophodon*) *floridanus*. The type, an r.M_3, is the only tooth mentioned in the original description of 1886; the numerous teeth from the same locality or horizon upon which subsequent descriptions were based (1896) become technically the metatypes rather than *paratypes*.

It has been a very difficult matter to designate positively the *type* specimen from Leidy's description, but the tooth shown in figure 377 has been finally selected, a third inferior molar of the right side, r.M_3. We observe that this beautifully sculptured tooth has the characteristic serridentine pattern in the fourth loph, on the outer side of the crown of the lower molars (compare Figs. 377 and 378) and on the inner side of the crown of the upper molars, so we have no hesitation in relating it to the genus *Serridentinus*,[1] although this Lower Pliocene species is much more progressive than the Upper Miocene species *S. productus* in the possession of five complete lophs and a quarter loph on the third inferior molars.

Side by side with this should be placed a drawing of the third superior molar tooth as shown in figure 378 B, which constitutes one



Ocalientinus (Serridentinus) floridanus Type and Metatypes

Fig. 379. Type and metatypes of *Mastodon* (*Trilophodon*) *floridanus* Leidy. 1886, 1896, one-fourth natural size. The accompanying figures represent an assemblage of the isolated teeth to which Leidy (1886.1, p. 12) assigned the name *Mastodon* (*Trilophodon*) *floridanus* and which were figured by Leidy and Lucas (1896, Pls. I–VII).

A, Crown view of type tooth (Nat. Mus. 3083), last lower right true molar, r.M_3 (cf. Leidy and Lucas, 1896, Pl. VI, fig. 1) Drawn from cast (Amer. Mus. 17725). A1, Side view of same tooth (cf. Leidy and Lucas, 1896, Pl. VI, fig. 2).

Among the metatypes are:

B, Left M_2 (cf. Leidy and Lucas, 1896, Pl. I, fig. 1), and left M_3 (cf. Leidy and Lucas, Pl. V, fig. 4), Nat. Mus. 3066; both drawn from cast (Amer. Mus. 14384)

C, Right M^1 [left M^1 *fide* Frick, letter, 1926] (cf. Leidy and Lucas, 1896, Pl. II, fig. 4).

D, Left M^1 [right M^1 *fide* Frick, letter, 1926] (cf. Leidy and Lucas, 1896, Pl. I, fig. 4).

E, Left M^2 (cf. Leidy and Lucas, 1896, Pl. I, fig. 4).

F, Left M^2 (cf. Leidy and Lucas, 1896, Pl. I, fig. 2).

G, Right M^3 (cf. Leidy and Lucas, 1896, Pl. V, fig. 2).

[1]See footnote on page 416.

of Leidy's *metatypes*. The relations of this metatype upper tooth to the type lower tooth is clearly shown in this figure (378 B and A). Thus the complete characters of the molars in *O.* (*S.*) *floridanus* are very clearly established in the type and metatype specimens belonging to the maxillary and mandibular series, which we have assembled in their mutual mechanical relations in our figure 379.

In the preparation of this Memoir the '*Mastodon*' *floridanus* species was originally referred by Osborn to the genus *Trilophodon*, the name shown in the printed legends on certain figures. It was transferred to the genus *Serridentinus* for two reasons: (1) The external and internal position and serrate borders of the trefoils, and (2) the apparently simultaneous use of the three grinding teeth in the adult stage. The measurements and indices of these teeth are as follows:

	ap.	tr.	I.		ap.	tr.	I.
M^2	125e	80e	64e	M_2	127	80	63
M^3	210	107	51	M_3	226	85	38

Before describing these in detail we may first speak of the geologic level and then proceed with Leidy's original description.

Geologic Level.—(Hay, 1923, p. 121): "16. *Archer, Alachua County* [Florida].—Dr. Joseph Leidy (Proc. Acad. Nat. Sci. Phila., 1886, p. 11) reported that Dr. W. H. Dall had discovered at Archer remains of a mastodon to which Leidy gave the name *Mastodon floridanus*. It is here referred to the genus *Gomphotherium*. It was associated in the Alachua clays with a species of *Hipparion*, three species of *Procamelus*, and a rhinoceros; also an astragalus of *Megatherium*. All of these, except the last, are usually referred to the Lower Pliocene or the Upper Miocene. The writer [Hay] believes that they belong to the lowest Pleistocene, the Nebraskan. 17. *Williston, Levy County.*—Leidy (Proc. Acad. Nat. Sci. Phila., 1887, p. 309) reported the finding of several species of fossil vertebrates in the Mixon bone-bed, at or near Williston. The species were *Gomphotherium floridanum*, *Hipparion plicatile*, *Procamelus major*, and *Teleoceras proterus*. These were found in the Alachua clays at depths from 2.5 to 6 feet. In Dall's list of 1892 (Bull. U. S. Geol. Surv. No. 84, p. 129) *Hipparion ingenuum* is included."

Osborn, 1923: Osborn regards this animal as of Middle or Upper Pliocene age, not Pleistocene, because of its frequent association with characteristic Upper Pliocene genera and species, such as *Hipparion*, *Procamelus*, and *Teleoceras*.

Osborn, 1933: Osborn is now (1933) of the opinion that it is of Lower Pliocene age.

Simpson, 1930.—In the Alachua and Bone Valley, Lower Pliocene, "*Serridentinus*" *floridanus* is very abundant.

History.—In the following notes it is very significant that Leidy himself compared this animal with "*Tetrabelodon*" *serridens* Cope and that Cope in his description of *T. serridens* noticed its resemblance to *M. floridanus*. Not until August, 1923, did Osborn fully realize that the *M. floridanus* of Leidy belonged to an entirely distinct generic phylum which in December of the same year he named *Serridentinus*.

Serridentinus floridanus is now (1933) transferred to the new genus *Ocalientinus* Frick, 1933, as fully described below (p. 433).

Original Description.—Leidy's original description and subsequent comments by Lucas, Osborn, and Merrill are as follows:

Mastodon (*Trilophodon*) *floridanus* Leidy, 1886. "Mastodon and Llama from Florida." Proc. Acad. Nat. Sci. Phila., 1886, Vol. XXXVIII, p. 12. Type Description.—"An unworn crown of a last inferior molar tooth resembles most nearly that of the *Mastodon angustidens* of Europe, but is much larger. It has the same number of crests, but the fifth is proportionately much more developed, being divided into two lobes, about two-thirds the size of those of the fourth crest. It is also much larger than in *M. andium*, and has its lobes proportionately more robust, and is provided with a well-produced external basal ridge. The following are comparative measurements of what appear the most closely allied forms:

	Fore and aft.	Transverse.
Florida mastodon [*O.* (*S.*) *floridanus*].	9 inches.	3½
M. angustidens.....	7¼ inches.	3½
M. andium.....	8 inches.	3

Small fragments of tusks indicate the possession of a band of enamel, as in the *M. angustidens*. For the species, the name of *Mastodon* (*Trilophodon*) *floridanus* was proposed."

Type.—"An unworn crown of a last [right] inferior molar tooth." Nat. Mus. 3083, cast Amer. Mus. 17725. Metatypes.—Left M_3, Nat. Mus. 3066, cast Amer. Mus. 14384; left M_2, cast Amer. Mus. 14384; right M^3, Nat. Mus., cast Amer. Mus. 17726, and other teeth. Type Figure.—(Leidy and Lucas, Trans. Wagn. Free Inst. Sci., Phila., 1896, IV, Pl. VI, figs. 1 and 2): "Fig. 1. Last lower right true molar. Fig. 2. Last lower right true molar. Outer aspect." (Osborn, 1921) This appears to be the tooth first mentioned by Leidy in his original description (*op. cit.*, 1886, p. 12) cited above; described and figured in a later paper (Leidy and Lucas, 1896, p. 37, pl. VI, fig. 1), and identified by him as a last lower molar of the right side.

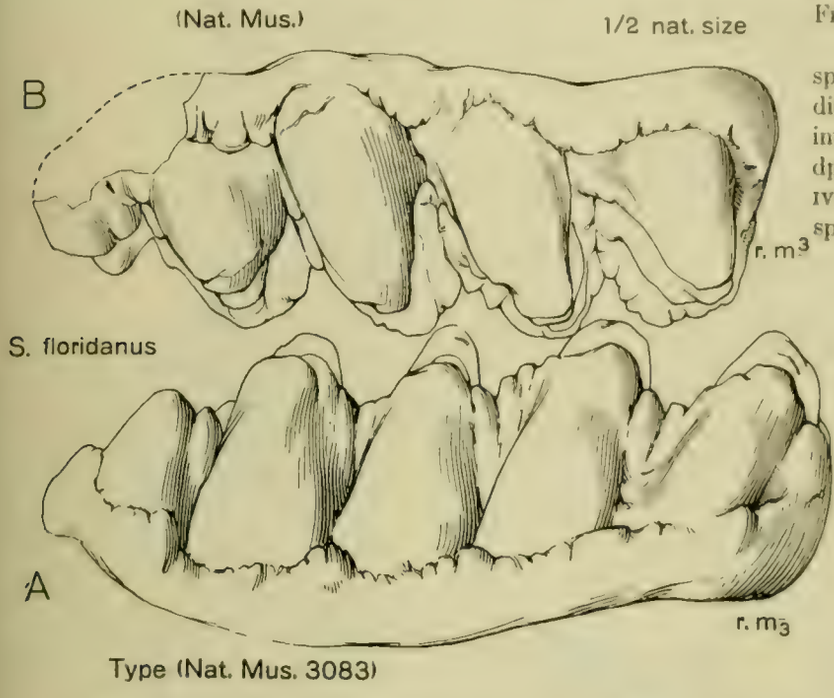
Type Localities and Metatype.—Collected by William H. Dall in the Alachua clays, Mixson's bone bed, near Williston, Levy County, Florida. The Alachua clays are of Lower Pliocene age. Hay (1923, p. 15) regards the Alachua clays as of lowest Pleistocene (i.e., Nebraskan age). Metatype and other Localities.—Leidy also reported (1887, p. 309) from the Mixson's bone bed, *Mastodon floridanus*, *Hipparion plicatile*, *Procamelus major*, and *Teleoceras proterus*. Sellards (1913, p. 58) reported the species from Juliette, Marion County, Fla., as of Lower Pliocene age.

Merrill (1907, p. 45) erroneously identified as type Nat. Mus. 3066. "*Mastodon floridanus* Leidy. Posterior portion of last left lower molar, associated with first and second left upper molars, probably of the same individual. Pliocene. Williston, Levy County, Florida."

Gidley (letter, March 30, 1922) correctly writes: . . . "but according to my determination made sometime ago and verified again yesterday the type of this species is a last lower molar of the right side (Cat. [Nat. Mus.] No. 3083). There can be no doubt that this tooth is the one first described by Leidy, as there is no other in the collection which agrees with this description and the measurements given by Leidy, while this one agrees in every detail. (See Proc. Acad. Nat. Sci. Phila., 1886, p. 11.)."

Osborn, 1921: (1) As compared with the specific types of *M. longirostris* and *M. campester*, this tooth, r.M_3, is in an earlier stage of evolution; (2) this tooth belongs in the Serridentinæ, with five complete crests and a bilobed talon crest; (3) it differs in the strong external cingulum, an exceptional feature in a lower molar, and (4) in trefoils strongly developed on outer side; (5)

Leidy (*op. cit.*, 1896, p. 18) distinguished it from '*Tetrabelodon*' *serridens* Cope; (6) compared the type with referred specimens or metatypes of *M. floridanus*, also (p. 20) with teeth obtained from Florida by Hatcher in 1890; (7) *M. floridanus* has advanced beyond the *M. productus* stage, showing the rudiments of a double trefoil, with five distinct crests and a posterior tubercle.

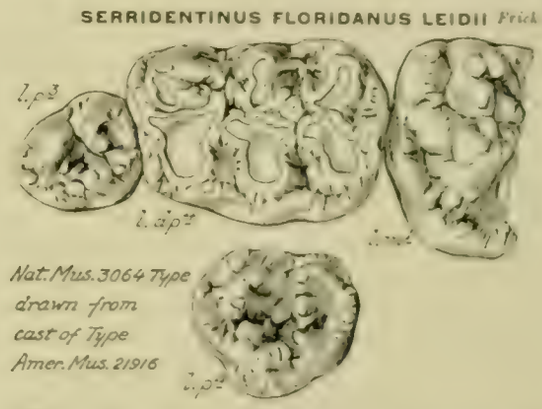


SECOND TYPE AND METATYPE FIGURES OF OCALIENTINUS (SER.) FLORIDANUS

Fig. 380. Type and metatype molars of *Mastodon* (*Trilophodon*) *floridanus*. One-half natural size. Observe forward inclination of lophs in both superior and inferior grinders. A, Type (Nat. Mus. 3083), a third right inferior molar, r.M_3. B, Metatype (Nat. Mus.) a third right superior molar, r.M^3.

quence in Certain Trilophodont Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LVI, Art. II, pp. 137, 140, 141, 155, 169. TYPE.—Immature maxillary specimen containing l.P^3, l.P^4 in germ beneath Dp^4, and l.M^1 (broken). Nat. Mus. 3064. HORIZON AND LOCALITY.—Lower Pliocene, Mixson's bone bed, near Williston, Levy County, Florida. TYPE FIGURE.—Leidy and Lucas, 1896, Pl. IV, figs. 9–11 (=Figs. 20A,B of Frick, 1926, Fig. 176 of the present Memoir); see also figure 381.

TYPE DESCRIPTION.—(Frick, 1926, p. 169): "This Florida specimen [type M_3 of *Mastodon floridanus*] represents an individual differing as conspicuously in size from that prophesied by the Leidy immature maxillary specimen (containing p^3, p^4 in germ beneath dp^4, and m^1 (broken), Nat. Mus. 3064, figured Leidy, 1896, Pl. IV, this paper, in part, Figs. 20A to C [B]), as do the larger Santa Fé specimens from the type of *T.* (*S.*) *productus*. I, therefore, suggest



TYPE OF OCALIENTINUS (SERRIDENTINUS) FLORIDANUS LEIDII

Fig. 381. New figure of the type teeth of *?Trilophodon* (*Serridentinus*) *leidii* Frick, 1926 (see original type figure Frick, 1926, p. 140, figs. 20A, B = Fig. 176 of present Memoir). One-half natural size. These teeth, consisting of l.P^3, l.P^4, l.Dp^4, l.M^1 (Nat. Mus. 3064, cast Amer. Mus. 21916) bear a strong resemblance to the teeth of *Ocalientinus* (*Ser.*) *floridanus* (Fig. 379 C, D).

Ocalientinus (Serridentinus) floridanus leidii
Frick, 1926

Figures 176, 177, and 381

Lower Pliocene, Alachua clays, Mixson's bone bed, near Williston, Levy County, Florida. Compare *Mastodon* [=*Ocal.* (*Ser.*)] *floridanus*, Leidy, 1886.

The type of this species is a maxillary specimen containing, besides Dp^4 and M^1 (Fig. 381), the third and fourth superior premolars, P^3 with P^4 in germ, which reveal characters not previously described. *?Trilophodon* (*Serridentinus*) *leidii*[1] Frick is regarded by the present author as a probable synonym of *O.* (*Ser.*) *floridanus*.

In 1896 Leidy and Lucas figured as *Mastodon floridanus* an immature maxillary specimen containing P^3, with P^4 in germ beneath Dp^4, and M^1, which Frick ("Tooth Sequence in Certain Trilophodont Tetrabelodont Mastodons," 1926) makes the type of a new species, (?)*Trilophodon* (*Serridentinus*) *leidii*, owing to the very marked difference in size from the large type of *M. floridanus*, thus indicating a smaller Florida race; it is also distinctive in the peculiar form of P^4. Frick in his paper of 1926 remarks that while the premolar status somewhat parallels that in *Trilophodon*, it represents a stage slightly in advance.

?Trilophodon (*Serridentinus*) *leidii* Frick, 1926. "Tooth Sequence in Certain Trilophodont Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LVI, Art. II, pp. 137, 140, 141, 155, 169. TYPE.—Immature maxillary specimen containing l.P^3, l.P^4 in germ beneath Dp^4, and l.M^1 (broken). Nat. Mus. 3064. HORIZON AND LOCALITY.—Lower Pliocene, Mixson's bone bed, near Williston, Levy County, Florida. TYPE FIGURE.—Leidy and Lucas, 1896, Pl. IV, figs. 9–11 (=Figs. 20A,B of Frick, 1926, Fig. 176 of the present Memoir); see also figure 381.

TYPE DESCRIPTION.—(Frick, 1926, p. 169): "This Florida specimen [type M_3 of *Mastodon floridanus*] represents an individual differing as conspicuously in size from that prophesied by the Leidy immature maxillary specimen (containing p^3, p^4 in germ beneath dp^4, and m^1 (broken), Nat. Mus. 3064, figured Leidy, 1896, Pl. IV, this paper, in part, Figs. 20A to C [B]), as do the larger Santa Fé specimens from the type of *T.* (*S.*) *productus*. I, therefore, suggest that this maxillary specimen, indicative of a smaller Florida race, be taken as the type of a new species, (?) *T.* (*S.*) *leidii*. The specimen is of unusual interest, not only in displaying associated p^3 and p^4, the vertical replacement of dp^4, and the former presence of a long-rooted tooth (?dp^2) anterior to p^3, but as well in the peculiar form of p^4 (Figs.16A-D; 20A-C [B]), and its position below the anteroinner corner of dp^4, which suggests that the tooth would erupt out of the normal position (and perhaps as in *T. turicensis*)."

Osborn, 1926: The superior premolars, P^3 and P^4, constituting a portion of the type of *Serridentinus floridanus leidii*, are very different from those of *S. proavus* (Fig. 363) and of *S. serridens* (Fig. 390); they either represent a distinct species or they may belong to the as yet imperfectly described superior premolars of *S. floridanus*.

Ocalientinus (Serridentinus) obliquidens[1] Osborn, 1926

Figures 382-385

Upper Pliocene, redeposited in Lower Pleistocene. Type and paratype from phosphate beds near Charleston, South Carolina. Referred from Tarboro, Edgecombe County, North Carolina.

This final Pliocene stage, distinguished by the elevated, compressed, and extremely oblique ridge-crests, appears to belong

[1]Referred by Osborn (1933) to the new genus *Ocalientinus* Frick.

in Adaptation A, with roundly blunted cones and conelets, adapted to the more luxuriant foliage of the eastern coast; it is not improbably the last of the eastern race of *Serridentinus*.

Serridentinus obliquidens Osborn, 1926. "Additional New Genera and Species of the Mastodontoid Proboscidea." Amer. Mus. Novitates, No. 238, November 30, 1926, p. 9. TYPE.—A left inferior molar, l.M_3, from the Cohen Collection (Amer. Mus. 13710). PARATYPE.—A left superior molar, l.M^3, also from the Cohen Collection (Amer. Mus. 13710a). HORIZON AND LOCALITY.—Upper Pliocene, redeposited in Pleistocene phosphate beds near Charleston, South Carolina. TYPE FIGURE.—Osborn, 1926.706, p. 9, fig. 7.

The single type (Fig. 382A) left inferior molar, l.M_3, of *Serridentinus*[1] *obliquidens* (Amer. Mus. 13710, Cohen Collection), *redeposited* in Pleistocene phosphate beds of South Carolina, is a very progressive form distinguished, as indicated by the specific name *obliquidens*, by its lophs, forwardly oblique, strongly elevated, sharply compressed and procumbent, from Leidy's '*M.' floridanus;* the crown is also narrower, smaller, and less massive in dimensions. The ridge-crest formula is apparently the same, namely, proto,-meta-, trito-, tetartolophids, bilobed pentalophid, and strong rudiment of a hexalophid (feeble in *floridanus*). The paratype, an l.M^3 (Fig. 382 B1, B2), also from the Cohen Collection (Amer. Mus. 13710a), reinforces the characters of this species, namely: (1) Internal trefoil spurs rising into single trefoil conelets; (2) summits of cones cleft into two low conelets; (3) summits of internal and external cones closely appressed; (4) absence of external cingulum; (5) ridge-crests probably (?) four and a third. The number of upper and lower ridge-crests is somewhat uncertain, because both type and paratype lack the anterior portion of the crown.

MATERIALS.—Besides the type and paratype specimens from the phosphate beds of South Carolina is a third right superior molar, r.M^3 (Fig. 382 C1, C2, Fig. 384), from Tarboro, North Carolina (Nat. Mus. 426, cast Amer. Mus. 10800), erroneously identified by Merrill (1907, p. 45) as the type of *Mastodon obscurus*.

PLIOCENE AGE.—The type (Amer. Mus. 13710) is from the Cohen Collection made in the phosphate beds near Charleston, S. C., and presented to the American Museum in 1908 by Mrs. Morris K. Jesup. Bearing on the Pleistocene age of the Charleston phosphate beds of the type locality, this collection also contains the following referred materials: Thirty-seven superior and inferior grinding teeth referred to *Parelephas columbi*, all from the phosphate beds near Charleston, S. C., belonging to the Cohen Collection, namely, Amer. Mus. Nos. 13707 (neotype), 13708 a-z, 13708 aa-ll, 13709. These teeth will be fully enumerated and described in Volume II, Chapter XVII, under *Parelephas columbi*.

REFERRED.—It is a matter of great historic interest to describe and refigure (Fig. 382 C1, C2) with this type (Amer. Mus. 13710) the classic fragment (Nat. Mus. 426, cast Amer. Mus. 10800) from Tarboro, N. C., a right superior molar, r.M^3. This Tarboro molar fragment (Fig. 382 C1, C2, and Fig. 384) was erroneously regarded by Doctor Merrill in the Catalogue of the National Museum collections as Leidy's type of *Mastodon obscurus*, an error corrected in our revision of the species *M.* [= *Trilophodon*] *obscurus* (see p. 285). We may also reproduce Leidy's original figure (Fig. 384) of this Tarboro specimen.

[1]Referred by Osborn (1934) to the new genus *Ocalientinus* Frick.

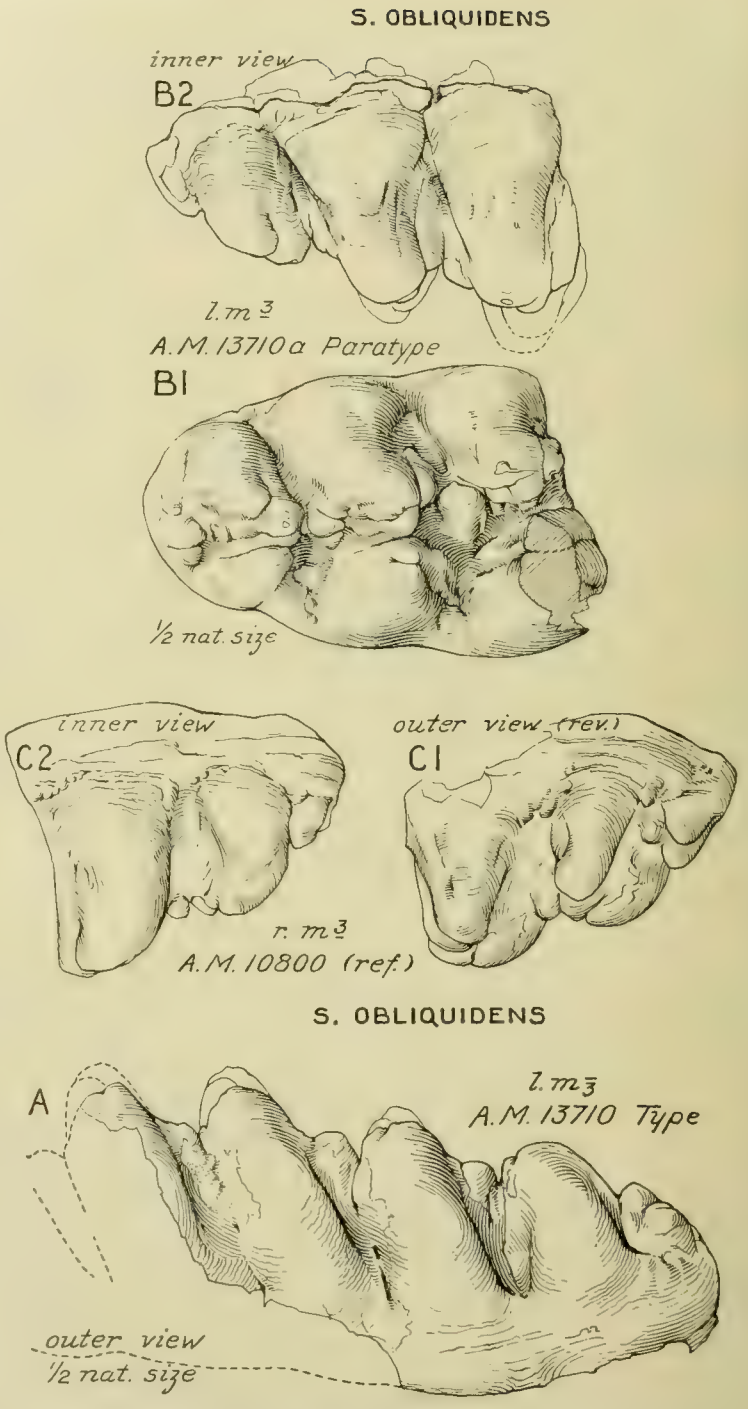


Fig. 382. OCALIENTINUS (SERRIDENTINUS) OBLIQUIDENS OSBORN, TYPE, PARATYPE, AND REFERRED MOLARS (A, B1, B2, C1, C2), ONE-HALF NATURAL SIZE

A, Type left inferior molar, l.M_3 (Amer. Mus. 13710), from the phosphate beds near Charleston, S. C., Cohen Collection. *Redeposited from Pliocene.*

B1, B2, Paratype left superior molar, l.M^3 (Amer. Mus. 13710a), from the phosphate beds near Charleston, S. C., Cohen Collection, consisting of tritoloph, tetartoloph, and small bilobed pentaloph. B1, Crown view; B2, internal view.

C1, C2, Referred right superior molar fragment, r.M^3 (Nat. Mus. 426, cast Amer. Mus. 10800), from Tarboro, North Carolina (compare Fig. 384). C1, External aspect (rev.), C2, internal aspect, of tooth represented in crown view (Fig. 384).

Specific Characters.—The broken left inferior molar type consists of the posterior half of the metalophid and the succeeding third, fourth, fifth, and rudimentary sixth (or hexalophid) crests, by comparison with *Ocal.* (*S.*) *floridanus*. (1) Besides the extreme ridge-crest obliquity, procumbency, external compression, and rudiment of a hexalophid above mentioned, this specific stage is distinguished (2) by single but very prominent trefoil spur conelets, especially behind the second, third, and fourth cones. (3) These trefoil spur conelets are single instead of multiple, or serrate, as in many species of *Serridentinus*. The above characters are clearly portrayed in the type figure (Fig. 382 A). The reference of the right superior molar, r.M³ (cast Amer. Mus. 10800), to this species is too uncertain to base a specific determination upon it.

The following measurements and comparisons indicate that *Ocalientinus* (*Ser.*) *obliquidens* is a more recent and more progressive species than, but probably not a descendant of, *Ocal.* (*Ser.*) *floridanus*.

Fig. 383. Type (middle) and paratype (lower) of *Ocal.* (*Ser.*) *obliquidens* Osborn (Amer. Mus. 13710 and 13710a), phosphate beds, near Charleston, South Carolina, compared with (upper) *Mastodon americanus* ref. (Amer. Mus. 13711) from the same locality and collection. One-fourth natural size.

(Upper) Portion of a superior molar of *Mastodon americanus* ref. (Amer. Mus. 13711) inserted for comparison.

(Middle) Type third inferior molar, l.M$_3$, of *Ocal.* (*Ser.*) *obliquidens* (Amer. Mus. 13710).

(Lower) Paratype of *Ocal.* (*Ser.*) *obliquidens*, consisting of the posterior half of a third superior molar, l.M³ (Amer. Mus. 13710a).

This original drawing represents the crown view of the original *type* specimen (middle) in the American Museum collection, readily distinguished from *Ocal.* (*Ser.*) *floridanus* by the lateral compression of the molar crowns and from *Trilophodon obscurus* by the oblique and elevated position of the ridge-crests.

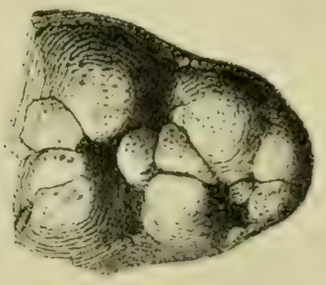


Fig. 384. After Leidy. Portion of third right superior molar, r.M³, of *Ocal.* (*Ser.*) *obliquidens* ref. (Nat. Mus. 426, cast Amer. Mus. 10800), Leidy, 1869, Pl. xxvii, fig. 16. Compare Leidy, *op. cit.*, p. 470, fig. 16: "*Mastodon obscurus*. . . . View of the triturating surface of the back part of a last inferior molar. From Tarboro, North Carolina. Half the natural size." On pages 247 and 248 Leidy describes this specimen. Lateral views of the same specimen are shown in figure 382 C1, C2 of the present Memoir. The parts shown in this figure and in figure 382 C1, C2 are the tritoloph, smaller tetartoloph, and rudimentary pentaloph.

This high-crowned upper grinder is quite distinct from Leidy's low-crowned Maryland type of *M.* [= *Trilophodon*] *obscurus*.

Comparative Measurements in Millimeters	*Ocal.* (*Ser.*) *floridanus* Type (cast Amer. Mus. 17725)	*Ocal.* (*Ser.*) *obliquidens* Type (Amer. Mus. 13710); Ref. (cast Amer. Mus. 10800)	
	Type r.M$_3$	Type l.M$_3$	Ref. r.M³
Anteroposterior	226	193e	170e
Transverse	85	83e	84
Height of metalophid from base of crown	79	72	
Height of tritolophid	83 (paratype)	79	67
Height of tetartolophid	80		
Height of tetartoloph			79

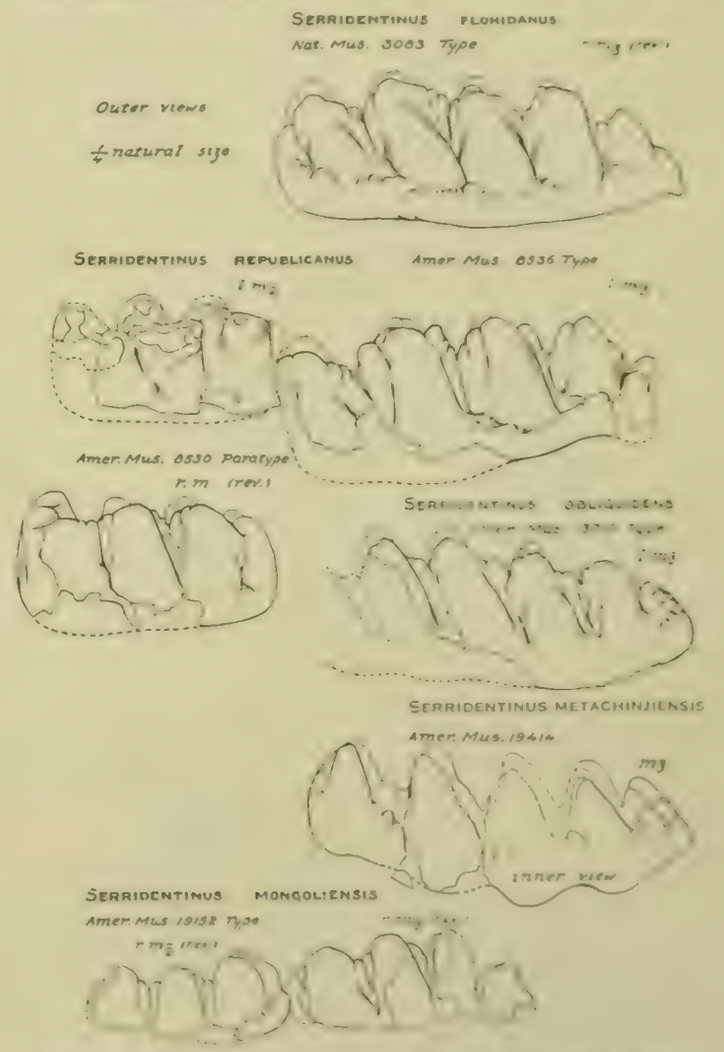


Fig. 385. Comparison of the inferior grinding teeth of three species of *Ocalientinus* and two of *Serridentinus*.

Ocalientinus (*Ser.*) *floridanus* type (Nat. Mus. 3083, cast Amer. Mus. 17725), an r.M$_3$ (rev.).

Ocalientinus (*Ser.*) *republicanus* type (Amer. Mus. 8536), l.M$_{2-3}$; paratype (Amer. Mus. 8530), r.M$_2$ (rev.).

Ocalientinus (*Ser.*) *obliquidens* type (Amer. Mus. 13710), l.M$_3$.

Serridentinus metachinjiensis type (Amer. Mus. 19414), r.M$_3$.

Serridentinus mongoliensis type (Amer. Mus. 19152), r.M$_{2-3}$ (rev.).

All figures to the same scale, namely, one-fourth natural size, to demonstrate the progressive elevation or subhypsodonty of the lophs and the addition of a fifth inferior crest in *Ocalientinus* (*Ser.*) *floridanus*.

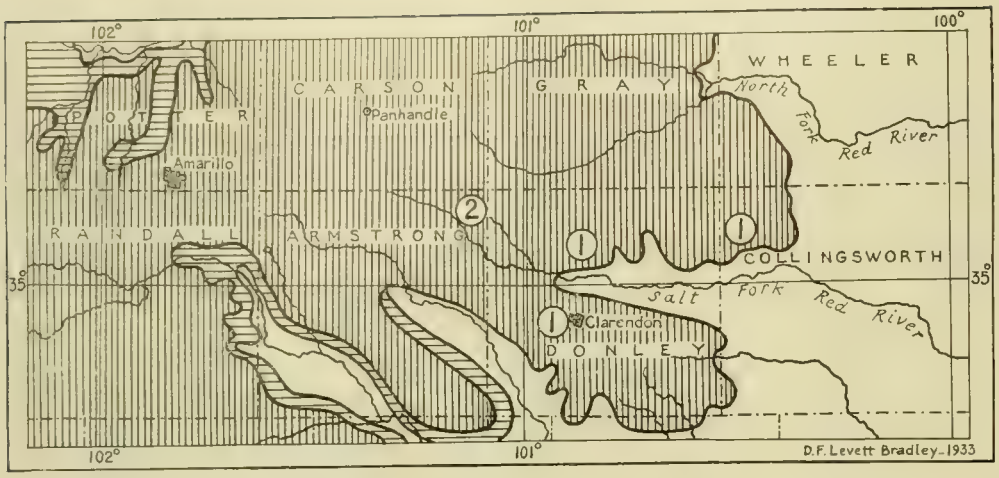
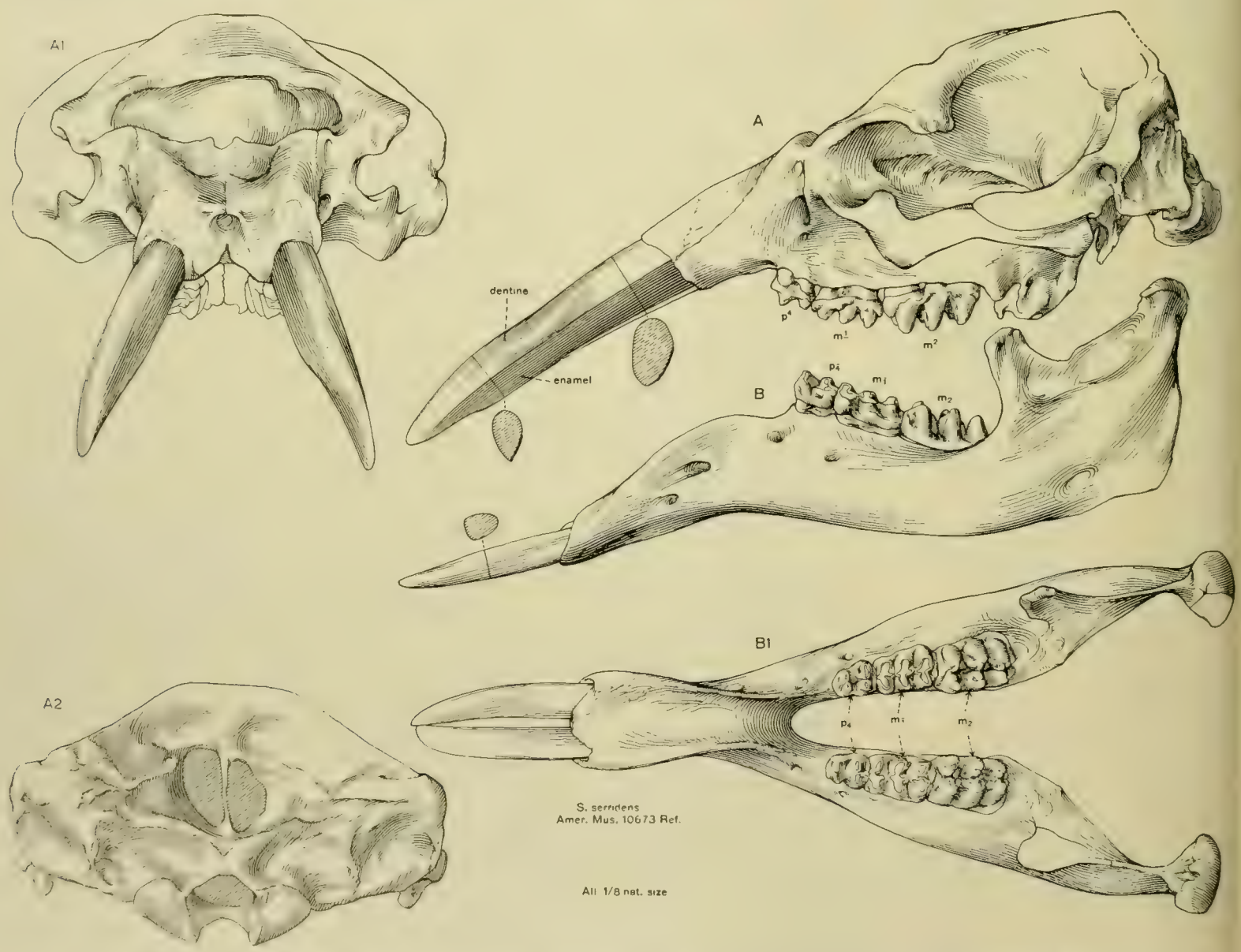


Fig. 386. 'Staked Plains' of northern Texas. Exposures of Clarendon horizon, of Upper Miocene to Lower Pliocene age. Also Lower Pleistocene *Archidiskodon imperator* and Upper Pleistocene *Equus scotti* quarries of northern Texas. Compare figure 358, p. 399.

(1) Clarendon horizon, Lower Pliocene, *Serridentinus serridens* life zone.

(2) Goodnight horizon, Pliocene.



YOUNG ADULT SKULL AND JAWS OF SERRIDENTINUS SERRIDENS, CLARENDON OF TEXAS. UNERUPTED THIRD SUPERIOR MOLAR

Fig. 387. Skull and jaws of young adult *Serridentinus serridens* ref. (Amer. Mus. 10673), found in the Lower Pliocene, Clarendon formation of Texas, by J. W. Gidley, Amer. Mus. Expedition of 1901. The same dentition is shown on a larger scale and more accurately in figure 390. All figures one-eighth natural size. This skull was crushed vertically by rock pressure and conveys an erroneous impression both of the anterior (A 1) and occipital (A 2) aspects.

II. Ascending Phylum (B). Sharp Ridge-crests. Trefoil spurs less dominant than in Ocalientinus

ASCENDING PHYLUM (B) OF SPECIES OF SERRIDENTINUS, WITH RIDGE-CRESTS PROGRESSIVELY ELEVATED AND SHARPENED; RIDGE-CRESTS WITH TREBLE OR QUADRUPLE INTERNAL (UPPER) AND EXTERNAL (LOWER) CONELETS. TREFOIL SPURS FINELY SERRATED. THE SHARPENED GRINDING TEETH IN THE SPECIES BELOW WERE APPARENTLY ADAPTED TO THE LESS SUCCULENT VEGETATION OF THE MORE ARID PLATEAUS AND UPLANDS OF THE PLIOCENE OF THE SOUTHERN AND WESTERN UNITED STATES

7. PROGRESSIVE PLAINS- AND DESERT-LOVING SPECIES OF NEBRASKA, TEXAS, FLORIDA, AND GUATEMALA

Serridentinus serridens Cope, 1884

Figures 170, 171, 342, 347, 348, 366, 387–390

Clarendon formation, Lower Pliocene of Texas.
Compare *Serridentinus serridens cimarronis* Cope, 1893.

Serridentinus serridens is certainly a distinct species characteristic of the Lower Pliocene Clarendon beds of Texas; it is more progressive in structure than *S. anguirivalis* and shares with that species the relatively high, compressed cutting cones and crests of Adaptation B of *Serridentinus*. Represented by a beautiful skull with jaws (Figs. 366 and 387), it is one of the best known of all species of *Serridentinus*. See also the Frick Collection, New Mexico (Sec. 8 below), and supplementary observations of Frick and of Simpson (p. 440).

HISTORY.—This stage from the Lower Pliocene of Texas, originally described by Cope in 1884, was confused for a time by Osborn with Cope's *Mastodon productus* from the Santa Fé marls, because the measurements of the intermediate molar teeth are so closely similar. Owing to this erroneous identification of the two

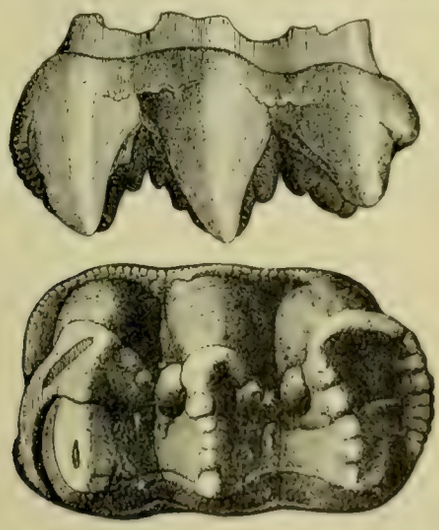
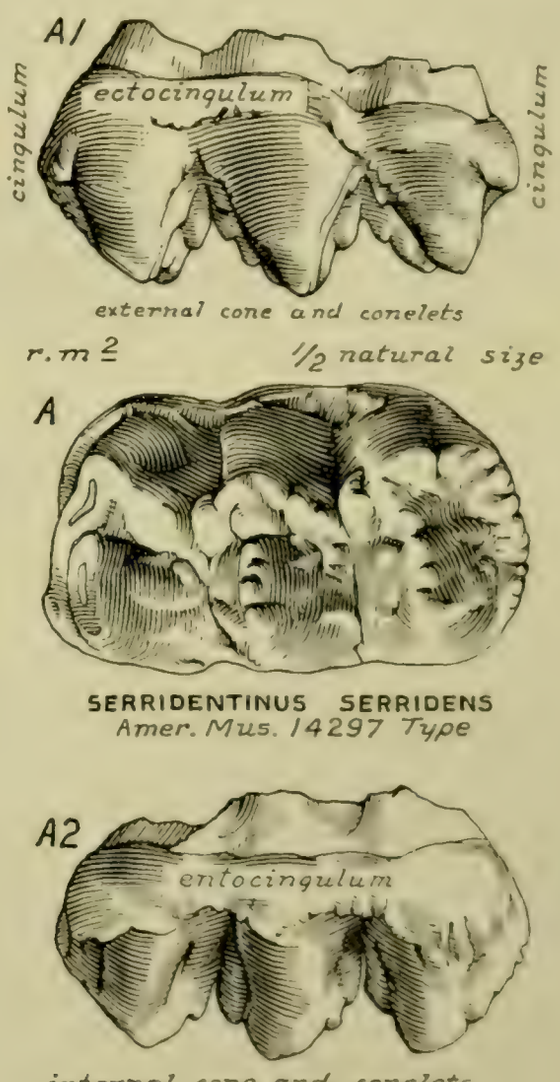


FIG. 8. *Tetrabelodon serridens* Cope; ?first molar. Typical specimen from ?Pliocene of Texas. Four-ninths natural size. Original.



ORIGINAL AND NEW FIGURES OF THE TYPE OF SERRIDENTINUS SERRIDENS

Fig. 388. Original figure of Cope's type upper molar of *Mastodon serridens*, 1884. After Cope, 1889.2, p. 205, fig. 8, figured as *Tetrabelodon serridens*. Amer. Mus. Cope Coll. 14297. Four-ninths natural size.

This is an unworn second superior molar of the right side, r.M², as shown by comparison with the corresponding tooth in figure 390. It is recognized as a superior molar by the presence of *quintuple* to *sextuple* conelets on the lophs

Fig. 389. Cope's type upper molar of *Mastodon serridens* (Amer. Mus. Cope Coll. 14297), Lower Pliocene (Clarendon), Texas. Second type figure prepared for this Memoir, one-half natural size.

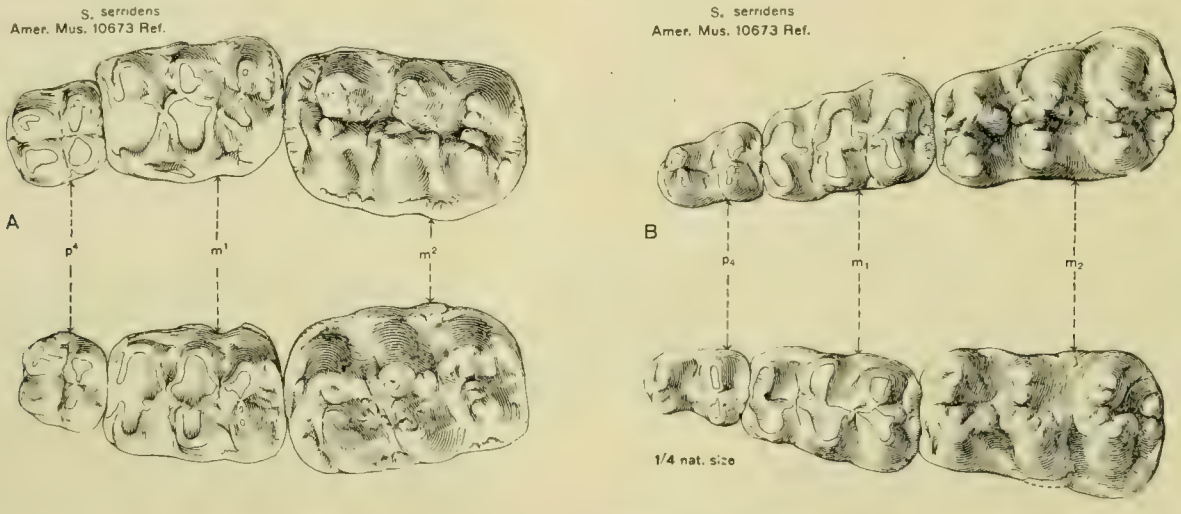
A second superior molar of the right side: upper drawing, external view; middle drawing, crown view; lower drawing, internal view. This figure was drawn under the impression that it was a lower molar; it proves to be a right M², distinguished by quintuple to sextuple conelets; rudimentary tetartoloph conelets broken off.

species, certain of the figures in the present Memoir were printed *Trilophodon productus serridens* or *T. serridens productus*. Osborn subsequently observed (Fig. 364) that the palatal aspect of the cranium in the two species was quite different; also that both species belonged to *Serridentinus* and not to *Trilophodon*.

M. [*Mastodon*] *serridens* Cope, 1884. "The Mastodons of North America." Amer. Naturalist, Vol. XVIII, 1884, p. 525. Type.—A second superior molar, r.M^2 (Amer. Mus. Cope Coll. 14297). Horizon and Locality.—(Cope, 1889.2, p. 205): "Typical specimen from ?Pliocene of Texas." (Osborn, 1921): The formation is probably the Clarendon of Texas, which yielded the fine skull and jaws of the American Museum expedition of 1901, also *Protohippus*, early Lower Pliocene. Type Figure.—Cope, 1889.2, p. 205, fig. 8, under the name *Tetrabelodon serridens*.

crown, 130 mm.; width, 80 mm.; height, 61 mm. (6) Similar to the subsequently described *M. floridanus* of Leidy.

Osborn, 1923: The unworn type molar of '*Mastodon*' *serridens* represents a second superior molar of the right side, r.M^2. Cope's type figure reproduced in facsimile herewith (Fig. 388) exhibits the distinctive *sextuple* conelets of the unworn protoloph and metaloph, also the outer aspect of the crown (which has been inverted in order to see it in its natural position) exhibits trefoils springing from the internal side of the internal lobes. The new type figure (Fig. 389) is also inverted to show the natural position of this tooth. The upper drawing represents the outside surface, the middle drawing the crown surface, the lower drawing the inside surface, which is strongly cingulate. The type molar of *M. serridens* which, as Cope truly observes, is analogous to the molars of *Mastodon turicensis* Schinz, thus serves



Dentition of Young Adult Serridentinus serridens Ref.

Fig. 390. Detailed structure of young adult *Serridentinus serridens* (Amer. Mus. 10673) fourth premolars and first and second molars only, P^4-P_4, M^1-M_1, M^2-M_2, contained in the skull illustrated in figure 366. One-fourth natural size. The same dentition is shown on a smaller scale and less accurately in figure 387.

Type Description.—(Cope, 1884.1, p. 525): "Founded on a first or second true molar from Texas. It is peculiar among American species in its acute elevated, entire crests, with tuberculo-serrate edges. It thus resembles the *M. turicensis*, but differs in well-developed longitudinal crests at the inner end of the external half of the crests, which consist of two tubercles on the posterior side of a crest, and on the anterior side of the next succeeding crest. Strong anterior and posterior cingula; edge of each cross-crest with six or seven tubercles. Length of crown, M. .130; width, .080; elevation, .061. Length of *M. ohioticus*, but narrower. Found by Henry Brous, M.D."

Cope's Supplementary Description (op. cit., 1889.2).—(1) Peculiar in its acute elevated, entire crests with tuberculo-serrate edges. (2) Well-developed longitudinal crests at the inner end of the external half of the lobes, consisting of two tubercles on the posterior side of a crest, and one on the anterior side of the next succeeding crest. (3) Strong anterior and posterior cingula. (4) Edge of each cross-crest with six or seven tubercles. (5) Length of

to bring out clearly the generic distinctions of *Serridentinus* from *Trilophodon* and *Turicius*.

Osborn, 1924: Osborn (1924) restores *Serridentinus serridens* as a species distinct from *Serridentinus productus*, and refers to this species the young adult skull and jaws in the American Museum collection (Amer. Mus. 10673) found in the Lower Pliocene of Texas by Gidley of the expedition of 1901; it exhibits three upper and lower grinders in use (Fig. 387), namely, P 4-M 2, the third superior and inferior molars, M^3-M_3, not yet having come into use.

Young Adult Skull and Jaws referred to Serridentinus serridens in the American Museum (Fig. 387)

This superb young adult skull from the Lower Pliocene of Texas exhibits the upper and lower tusks in their relatively unworn condition, whereas in Cope's type of *M. productus* (Fig. 367) and in the adult skull of *S. productus* described above (Fig. 370) both the lower and upper tusks are considerably worn. The narrow and deep tusk section and the position of the lateral enamel band are

beautifully shown in this drawing (Fig. 387 A) in contrast to the flattened or subtriangular section (B) of the lower tusks which are without enamel. The jaws are of the medilongirostral type and somewhat decurved, in contrast to the upward curvature characteristic of the *Trilophodon* jaws; six grinding teeth, above and below, are in use on each side, which may be homologized as P^4-M^2, P_4-M_2; the premolars (which may belong to the permanent or to the deciduous series) are bilophodont; the intermediate molars are trilophodont; there is still no trace of the third molars, M^3-M_3, in either jaw.

Crushing.—The cranium of this individual (Fig. 387) is flattened by rock pressure so that the anterior view (A1) and the occipital view (A2) are altogether out of proportion; this flattening is somewhat rectified in the drawing of the lateral view of the skull (A). The uncrushed skull of *Serridentinus* was undoubtedly rounded above like the skulls of *Trilophodon* and *Tetralophodon;* the chief difference between the skull of *Serridentinus* and that of *Trilophodon* is the abbreviation of the rostrum, maxillo-premaxillary above, and symphyseal portion of the mandible below.

Grinding Teeth of Serridentinus (Fig. 390).—The dentition of *Serridentinus serridens* is displayed in detail in the same skull (Amer. Mus. 10673); the detailed structure of the crowns of the grinding teeth is beautifully shown in this skull as illustrated in figure 390. The teeth in place are P^4-P_4, M^1-M_1, M^2-M_2. The fourth superior premolar (A) is tetrabunodont and differs entirely from a molar in form; this tooth, P^4, should be compared with the type premolar of *Serridentinus proavus* (Fig. 362), which is also tetrabunodont. The fourth inferior premolar (B) is also tetrabunodont but is elongate in form like the molars. The first superior molar (A) is trilophodont and half worn; the tritoloph is much narrower than the protoloph and metaloph. The first inferior molar (B) is relatively narrow, the tritolophid is more fully developed. The second superior molar (A) is also trilophodont, but the tritoloph is relatively broader than in M^1. The second inferior molar (B) is relatively long and narrow, broadening somewhat posteriorly. These are the teeth which are used in the diagram (Fig. 348 A) to show the reciprocal mechanical relations of the upper and lower teeth in the Longirostrinæ and Tetralophodontinæ.

Serridentinus anguirivalis Osborn, 1926

Figures 391 and 394

Lower Pliocene, Snake Creek formation (upper), Quarries 7 and 5, south-central Sioux County, western Nebraska.

The species *Serridentinus anguirivalis*, named after the Snake Creek formation of western Nebraska, as shown in the succeeding table, is represented by the type and paratype specimens (Amer. Mus. 17217, 19248e), also by four referred specimens (Amer. Mus. 19248g, h, i, k) from two different quarries of the same geologic age. This specific stage (Fig. 391) appears to be more primitive than the stage represented by Cope's *Mastodon* [=*Serridentinus*] *serridens* (Fig. 388).

Serridentinus anguirivalis Osborn, 1926. "Additional New Genera and Species of the Mastodontoid Proboscidea." Amer. Mus. Novitates, No. 238, November 30, 1926, p. 10. Type.—A second right superior molar, r.M^2 (Amer. Mus. 17217). Paratype.—Posterior portion of a right third superior molar, r.M^3 (Amer. Mus. 19248e), consisting of metaloph, tritoloph, and tetartoloph (Figs. 391, 394). Horizon and Locality.—Snake Creek B horizon (upper), Lower Pliocene, south-central Sioux County, Nebraska; type from Quarry 7, paratype from Quarry 5. Type Figure.—*Op. cit.*, 1926.706, p. 10, fig. 8. Referred.—The middle fragment of a superior tusk (Amer. Mus. 19248 i) and the end fragment of another tusk (Amer. Mus. 19248 g) exhibit a characteristic upper incisor section of *Serridentinus* flattened by wear on the internal side.

The type tooth (Fig. 391) of this species, a second right superior molar, r.M^2 (Amer. Mus. 17217), was erroneously determined by Osborn (1921.522, p. 3, fig. 1, A1) as belonging to *Mastodon* [=*Pliomastodon*, 1926] *matthewi* and described as a paratype of a genus and species from which it is entirely distinct. The same specimen was selected by the present author in 1926 (Osborn, 1926.706, p. 10) as the type of a new species, named *Serridentinus anguirivalis* in reference to its occurrence in the Snake Creek formation.

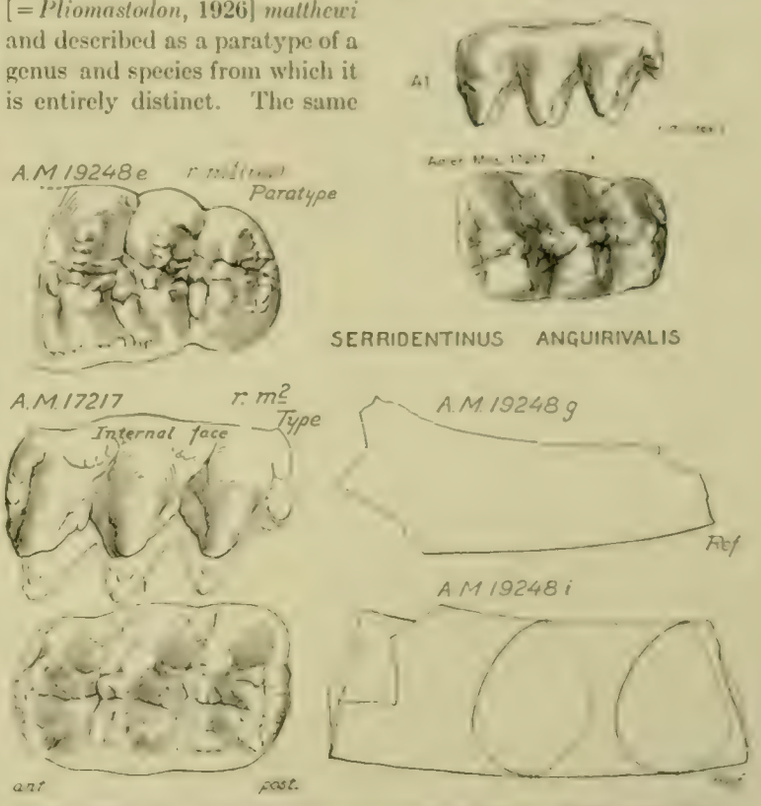
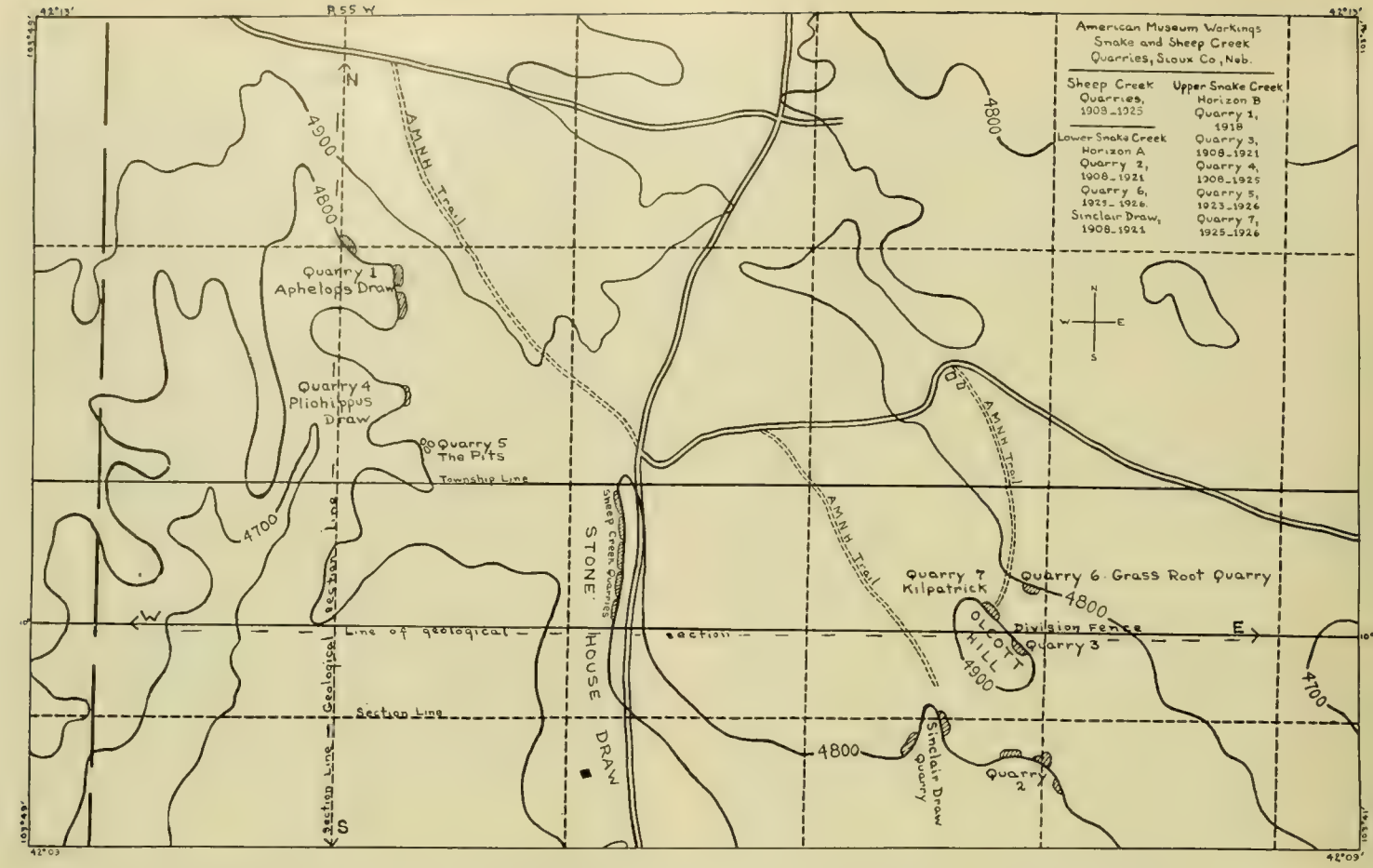


Fig. 391. Type of *Serridentinus anguirivalis* Osborn, 1926 (Amer. Mus. 17217), a second right superior molar, r.M^2. Paratype of same species, an r.M^3 (Amer. Mus. 19248e). Referred superior tusk fragments of same species (Amer. Mus. 19248i, 19248g). After Osborn, 1926.706, p. 10, fig. 8 (compare Fig. 394 showing type of *S. anguirivalis* in comparison with *S. nebrascensis*, *Pliomastodon*, and *Rhynchotherium* in the same horizon). A1, after Osborn, 1921.522, fig. 1. This r.M^2 was erroneously made the paratype of *Mastodon matthewi*; subsequently Osborn (1926.706, p. 10) made it the type of *Serridentinus anguirivalis*.

When closely compared with the corresponding type tooth, r.M^2 (Figs. 388 and 389), of the more progressive *Serridentinus serridens*, the present species *S. anguirivalis* is at once seen to be inferior in size and less progressive in form; the cones are slightly less elevated, e.g., metaloph (external 56 mm.), as compared with that of *S. serridens* (external 61 mm.). The type r.M^2 is supplemented by the paratype (Amer. Mus. 19248e), a right third superior



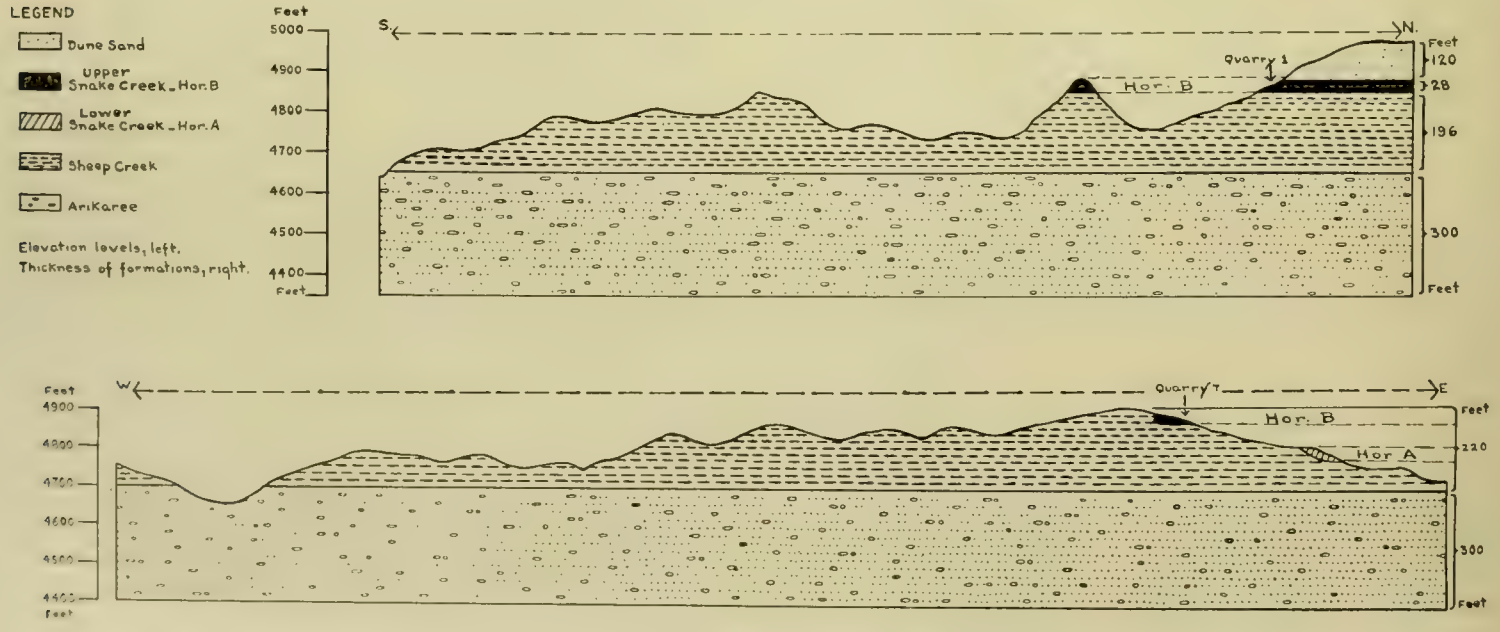
Sheep Creek to Snake Creek Exposures, South-central Part of Sioux County, Western Nebraska

Fig. 392. Corrected United States Geological Survey contour lines. Latitude, 42° 9′ to 42° 13′. American Museum quarries explored during the years 1908–1926.

Snake Creek B, upper, Lower Pliocene. *Pliohippus leidyanus* zone: Quarries 1, 3, 4, 5, 7, *Serridentinus anguirivalis, S. nebrascensis, Pliomastodon matthewi, Rhynchotherium anguirivalis.*

Snake Creek A, lower, Upper Miocene. *Merychippus paniensis* zone: Quarries 2, 6, *Alticamelus*, etc. No evidence of Proboscidea.

Sheep Creek quarries. *Merychippus primus* zone: *Blastomeryx*, etc. No evidence of Proboscidea.



Sections through Sheep Creek and Snake Creek Quarries

Fig. 393. Diagrammatic sections through Middle Miocene, Upper Miocene to base of Middle Pliocene, Snake Creek region, Sioux County, western Nebraska.

S–N North to south section (upper) taken along the eastern boundary of sections 21, 28, and 33, T. 26 N., R. 55 W., and sections 4 and 9, T. 25 N., R. 55 W., Sioux County, Nebraska.

W–E West to east section (lower) taken along the 42° 10′ latitude line in T. 25 N., between R. 54 W. and R. 55 W.

LOWER PLIOCENE, SNAKE CREEK B, SIOUX COUNTY, NEBRASKA. NUMEROUS MASTODONTS

ASSOCIATION IN THE SAME RIVER DRIFT LEVELS OF THE SNAKE CREEK FORMATION OF WESTERN NEBRASKA OF THE ISOLATED TYPE, PARATYPE, AND REFERRED SPECIMENS OF FOUR SPECIES BELONGING TO THE SUBFAMILIES SERRIDENTINÆ, MASTODONTINÆ, BREVIROSTRINÆ, AND RHYNCHOROSTRINÆ. IT IS PROBABLE THAT THESE SPECIMENS WERE TRANSPORTED FROM VARIOUS MORE OR LESS DISTANT AND DISTINCT HABITAT AREAS									
				SNAKE CREEK B Lower Pliocene					SNAKE CREEK A Upper Miocene		
			Quarry 1 (Aphelops Draw)	Quarry 4 (Pliohippus Draw)	Quarry 3 (Olcott Hill)	Quarry 7 (Kilpatrick Pasture)	Quarry 5 ("The Pits")	Quarry 2 (Sinclair Draw)	Quarry 6 ("Grass Roots")	Sheep Creek
17217	r.M²	*Serridentinus anguirivalis* Type				T				
19248e	r.M³	*Serridentinus anguirivalis* Paratype					×			
19248g	I²	*Serridentinus anguirivalis* Ref. (?)					×			
19248h		*Serridentinus anguirivalis* Ref. (?)					×			
19248i	I²	*Serridentinus anguirivalis* Ref. (?)					×			
19248k	r.M³	*Serridentinus anguirivalis* Ref.					×			
18237	r.M³	*Pliomastodon matthewi* Type	T							
18238	r.M₃	*Pliomastodon matthewi* Paratype	×							
18239	r.M₁	*Pliomastodon matthewi* Paratype	×							
19248a	r.M₃	*Pliomastodon matthewi* Ref.					×			
19248b	I²	*Pliomastodon matthewi* Ref.					×			
18240	r.M¹	*Serridentinus nebrascensis* Type	T							
21459	l.M¹	*Serridentinus nebrascensis* Ref.				×				
21452	r.Dp⁴	*Serridentinus nebrascensis* Ref.				×				
19248j		*Serridentinus nebrascensis* Ref.					×			
21451		*Serridentinus nebrascensis* Ref.					×			
21455		*Serridentinus nebrascensis* Ref.					×			
19250	r.M₃	*Rhynchotherium anguirivalis* Type			T					
21453	l.P²	*Rhynchotherium anguirivalis* Ref.				×				
21454	l.M³	*Rhynchotherium anguirivalis* Ref.				×				
19248c	l.M³	*Rhynchotherium anguirivalis* Ref.					×			
19248f	l.M³	*Rhynchotherium anguirivalis* Ref.					×			
19248d	Dp₃₋₄	*Rhynchotherium anguirivalis* Ref.		×						

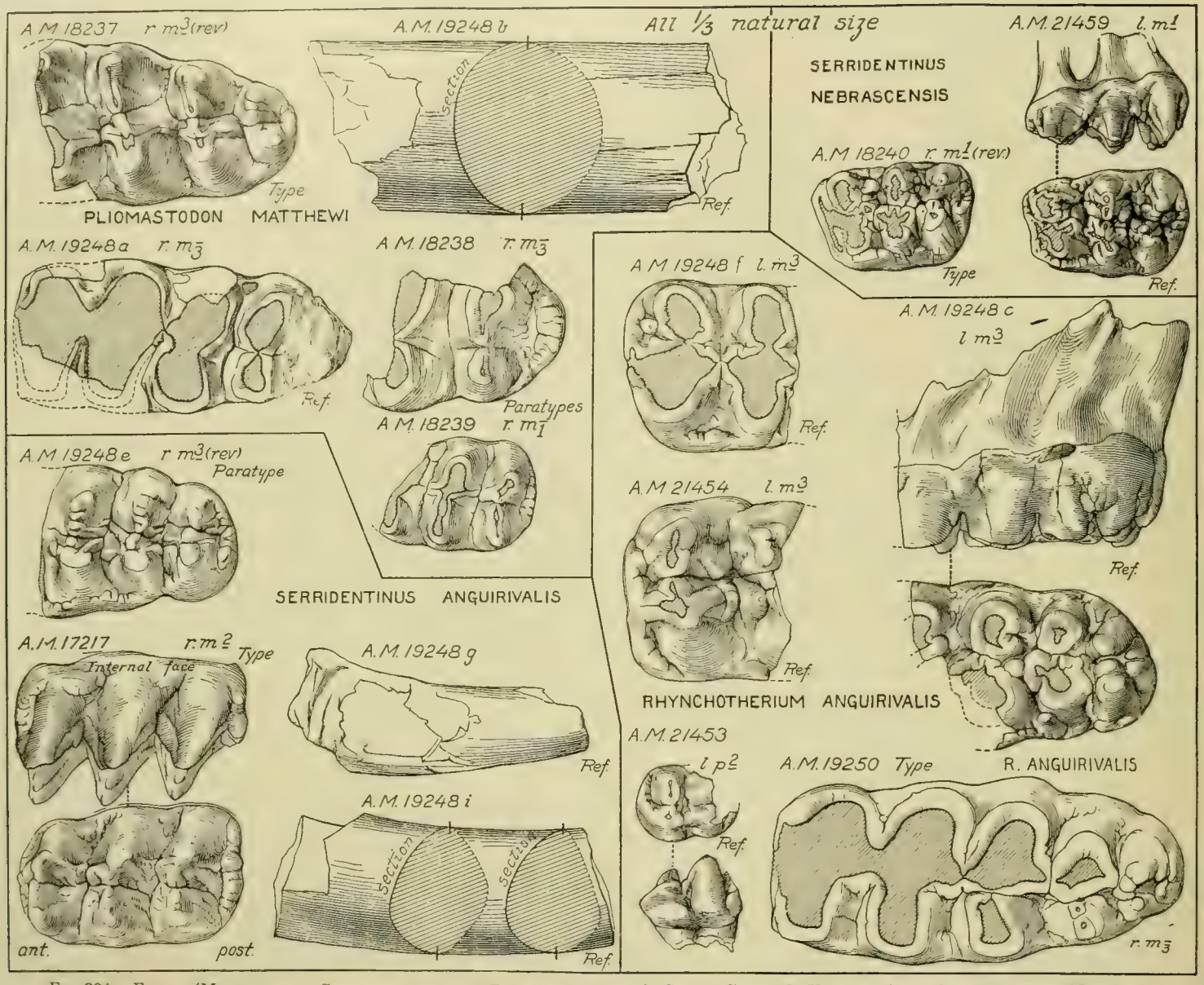


FIG. 394. FAUNA (MASTODONTS, SERRIDENTINES, AND RHYNCHOROSTRINES), SNAKE CREEK B HORIZON (UPPER), OF WESTERN NEBRASKA
ALL FIGURES ONE-THIRD NATURAL SIZE

Pliomastodon matthewi

Type and paratype grinding teeth, originally described by Osborn as *Mastodon matthewi* (Osborn, 1921.522, p. 2), subsequently (1922.564, p. 4) as *Miomastodon matthewi*. Type, a third superior molar, r.M^3 (Amer. Mus. 18237); paratypes, an inferior right third molar, r.M_3 (Amer. Mus. 18238), and first right inferior molar, r.M_1 (Amer. Mus. 18239); also referred r.M_3 (Amer. Mus. 19248a) and superior tusk, I^2 (Amer. Mus. 19248b); all isolated specimens representing different stages of wear. See Chapter VI, *Pliomastodon matthewi*.

Serridentinus anguirivalis

Type second right superior molar, r.M^2 (Amer. Mus. 17217), superior and internal aspects; paratype, third superior molar, r.M^3 (Amer. Mus. 19248e); also referred superior incisive tusks (Amer. Mus. 19248g, 19248i). See present Chapter X.

Serridentinus nebrascensis

Type, first right superior molar, r.M^1 (Amer. Mus. 18240); also referred first left superior molar, l.M^1 (Amer. Mus. 21459). See present Chapter X.

First erroneously described as *Stegomastodon nebrascensis* (Osborn, 1924), these two Lower Pliocene grinders of *Serridentinus nebrascensis* strengthen the correlation of the Snake Creek of Nebraska with the Alachua and Bone Valley of Florida.

Observe close resemblance of the type of *Ser. nebrascensis* and referred grinding teeth (r.M^1, Amer. Mus. 18240, l.M^1, Amer. Mus. 21459) with the corresponding premolar teeth (r.M^1, l.M^1) of *Ocalientinus* (*Ser.*) *floridanus* (Fig. 379 C, D of the present chapter).

Rhynchotherium anguirivalis

Type, r.M_3 (Amer. Mus. 19250), a well-worn right inferior grinding tooth; referred left third superior molars, l.M^3, well worn (Amer. Mus. 19248f), less worn (Amer. Mus. 21454), crown and side views of another referred left third superior molar, l.M^3 (Amer. Mus. 19248c), also a left superior premolar, l.P^2 (Amer. Mus. 21453). See Chapter XI.

Observe the very wide contrast between (a) the smooth, thin enamel of *Pliomastodon*, (b) the very thick, smooth enamel and blunt cones of *Rhynchotherium*, (c) the folded, chevrodont enamel of *Serridentinus nebrascensis*, (d) the thin, high-crested enamel of *S. anguirivalis*. These contrasts indicate that the Snake Creek (upper) mastodonts were washed in from many different local feeding habitats.

molar, r.M³, from Quarry 5, in which the metaloph has a similar elevation (internal, 52 mm.). This type and the paratype establish *S. anguirivalis* as a more primitive and smaller animal than *S. serridens.*

Faunal Level.—In the same faunal level, as shown in the figure (Fig. 394) on page 428, occur three other species of mastodonts, including the type, paratype, and referred specimens of *Pliomastodon matthewi*, the type and referred specimens of *Rhynchotherium anguirivalis*, and the type and referred specimens of *Serridentinus nebrascensis.* Each of these species is represented by several isolated specimens discovered in the various quarries of the Snake Creek B formation (upper), which the collector, Albert Thomson, considers as of the same geologic age.

	Serridentinus anguirivalis		*S. serridens*
	Type r.M²	Paratype r.M³	Type r.M²
Anteroposterior	121	145c	130
Max. width of protoloph	64	81c	80
Max. height of metaloph	60	52	61
Width of metaloph	75	86	79

Type Characters.—(1) Relative measurements as above, smaller and less progressive than *S. serridens.* (2) Trefoil spurs represented by low vertical ridges lacking the single or double conelets of *S. serridens.* (3) Postcingulum broad ending in a prominent single conelet; internal cingulum lacking; external cingulum rudimentary, rugose. (4) Internal cones bifid at summit.

Paratype Characters.—(1) Right third superior molar, r.M³, with four crests, protoloph (broken away), metaloph with five to six transverse conelets, tritoloph the same, tetartoloph with three transverse conelets. (2) Postcingulum rudimentary, internal cingulum strong in antero-internal portion.

Comparison with Serridentinus serridens.—These measurements and detailed characters prove that the *Serridentinus anguirivalis* of Nebraska is geologically more recent but less progressive than *S. serridens* of Texas, yet it apparently belongs in the same sharp-crested phylum; it is *more* progressive than *S. brewsterensis* of Florida.

Serridentinus nebrascensis Osborn, 1924

Figures 394 and 446

From Snake Creek, Sioux County, Nebraska, Quarry 1, Lower Pliocene.

Serridentinus nebrascensis, erroneously described (1924) by Osborn as '*Stegomastodon*,' based upon an r.M¹ (type) and an l.M¹ (see Fig. 394), may prove to be the same as the subsequently described *Serridentinus anguirivalis* Osborn, 1926, in which case *S. anguirivalis* becomes a synonym. For full description, see Appendix to the present Chapter X (p. 473).

Serridentinus serridens cimarronis Cope, 1893

Figure 395

East of Llano Estacado, north of south fork of Red River, Clarendon of Texas, Lower Pliocene, *Procamelus-Hipparion* zone.

The type of this subspecies has not been examined by the present author; thus we depend upon Cope's type figure, reproduced in our figure 395. Another uncertainty arises from the fact that the third superior molar of *Serridentinus serridens* is not fully known; as shown in figure 366 it is still buried in the skull. The high, compressed cones and extremely narrow, subtriangular posterior half of the crown relate this species to Adaptation B of the *Serridentinus* series.

This subspecies was established by Cope in 1893 on a misapprehension as to the position of the type specimen (Fig. 395) in the dental series, which he designated with a reservation as "a last inferior molar," but which is certainly to be regarded as a third superior molar of the left side, l.M³, as shown by comparison of Cope's type figure (Fig. 395) with figure 349 of the present Memoir. The proportions are not quite the same in the two drawings, but when we compare the two specimens the general resemblance is very close indeed. The geologic age, according to Cope, is the same and we may therefore regard *Tetrabelodon serridens cimarronis* as a synonym or subspecies of *S. serridens.*

T. [*Tetrabelodon*] *serridens cimarronis* Cope, 1893. "A Preliminary Report on the Vertebrate Paleontology of the Llano Estacado." Fourth Ann. Rept., Geol. Surv. Texas for 1892 (1893.1), pp. 18–20. Type.—A third superior molar of the left side, l.M³, Texas Geological Survey Collection, Austin, Texas. Horizon and Locality.—East of Llano Estacado, Texas, north of south fork of Red River, Clarendon beds, containing *Protohippus*, type of *M. serridens* Cope, and referred *M. productus* Cope.

Type of Serridentinus serridens cimarronis

Fig. 395. Type l.M³ of *Tetrabelodon serridens cimarronis* Cope, 1893, Pl. III, figs. 2 and 3, one-half natural size. East of Llano Estacado, Texas, north of south fork of Red River. Texas Geological Survey Collection.

A third superior molar of the left side, l.M³, erroneously identified by Cope as a third inferior molar. Upper figure reversed to show natural position.

(Osborn, 1918.473, p. 34): *Procamelus-Hipparion* zone. Type Figure.—(Cope, 1893.1, Pl. III, figs. 2, 3): Figure 2. "*Tetrabelodon serridens cimarronis*, Cope; last inferior [superior] true molar of left side, one-half natural size, from above. Figure 3. Same as figure 2, from inner side."

Type Description.—(Cope, 1893.1, p. 19): "I refer to this species with much reserve a last inferior molar, which is for the most part in excellent preservation. It resembles the intermediate molar on which the species [*S. serridens*] was established in most respects, but presents some important differences, among which is a relatively inferior size. The fact that the last molar exceeds very little in length the typical intermediate molar, renders the identification doubtful, unless it indicates a small race of the same species."

Type Characters.—(Cope, *op. cit.*, 1893.1, p. 19): (1) The molar (?) M_3 [M^3] supports only three crests and a well-developed heel; crests elevated with their apices contracted both longitudinally and transversely; (2) other characters like the type of *T. serridens*; (3) the specific differences of *T. serridens cimarronis* are as follows: "In the new tooth the internal half of the middle cross-crest has three tubercles; in the type there are four (one smaller). On the external half of this crest there is no tubercle besides the main cusp; in the type there is one, in line with four of the other half. The new tooth shows a single tubercle behind the main external cusp; in the type there are two. The posterior crest has in both teeth tubercles on the external half; on the internal half there are three, besides the principal in the type, and but one in the new tooth. In both teeth the internal part of the first cross-crest is not serrate. In the new tooth the heel consists of three obtuse tubercles, of which the external is the largest. The valley separating it from the crest in front is not blocked by a tubercle. Enamel smooth.

Measurements [l.M^3]

	Mm.
Total length of crown	140
Width of crown at first crest	80
Width of crown at second crest	76
Width of crown at third crest	68
Width of apex of first crest	49
Width of apex of third crest	36
Elevation of first crest from cingulum	46
Elevation of third crest from cingulum	43

As already remarked, this tooth is relatively smaller than the corresponding one in the type specimen should be. The latter should measure about 205 mm., whereas the length of the tooth now described is only 140 mm. It may pertain to a different species, but for the present I refer it to a small race of the *T. serridens*, under the name of *T. serridens cimarronis*."

Osborn, 1924: For the reasons above stated the type is regarded as a third superior molar of the left side which we believe will not be found to differ very widely from the corresponding tooth in *Serridentinus serridens* ref. (Amer. Mus. 10673).

Serridentinus brewsterensis Osborn, 1926

Figure 396

Lower Pliocene, Bone Valley formation, Brewster, Polk County, Florida.

We may regard *Serridentinus brewsterensis* as less progressive than the sharply crested *S. anguirivalis* (Fig. 391), *S. serridens* (Figs. 388, 389), and (?) *S. præcursor*[1] (Figs. 397, 398); it agrees with (?)*S. præcursor*[1] in the posterior narrowing of M^3 and in the presence of only four ridge-crests. See observations of Frick and of Simpson (p. 440 below).

The type of this species (Fig. 396), a third superior molar of the left side, l.M^3 (Amer. Mus. 1908), part of the collection of the American Cyanimid Company of Brewster, Florida, and presented to the American Museum by Mr. H. L. Mead in 1924, is from Brewster, Polk County, Florida, and is apparently distinct from any of the American species of *Serridentinus* heretofore described, although it may approximate the still unknown M^3 of *Serridentinus serridens*. The presence of only four ridge-crests in M^3, of strong trefoil spurs on each crest, and the extreme narrowness of the type tooth posteriorly, are three distinctive characters. This molar tooth is in a more progressive stage than that of *S. productus* ref. (Amer. Mus. 10582), but is less progressive than the *S. serridens* stage of Texas. It is clearly distinguished from *Ocalientinus* (*Ser.*) *floridanus* (Fig. 377) by the oblong, triangular form of the third superior grinder, which contracts rapidly to the narrow tetartoloph, also by four ridge-crests instead of five.

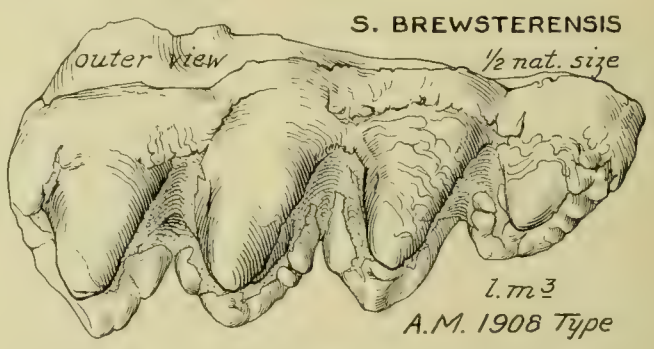


Fig. 396. Type third left superior molar, l.M^3, of *Serridentinus brewsterensis* (Amer. Mus. 1908), from Brewster, Polk County, Florida. After Osborn, 1926.706, p. 11, fig. 9, one-half natural size. Observe the much more primitive structure of this molar than that of the r.M^3 of *Ocalientinus* (*Ser.*) *floridanus* (Fig. 380).

Serridentinus brewsterensis Osborn, 1926. "Additional New Genera and Species of the Mastodontoid Proboscidea." Amer. Mus. Novitates, No. 238, November 30, 1926, p. 11. Type.—A third superior molar of the left side, l.M^3 (Amer. Mus. 1908). Horizon and Locality.—Lower Pliocene, Bone Valley formation, Brewster, Polk County, Florida. Type Figure.—Osborn, *op. cit.*, 1926.706, p. 11, fig. 9.

Type Characters.—Third superior molar with (1) four ridge-crests only, (2) the tetartoloph not more than two-thirds the height (elev. 45 mm.) of the protoloph (elev. 60 mm.), (3) total width of the tetartoloph (breadth 59 mm.) much less than the width of the protoloph (breadth 87 mm.), (4) total length of the crown (ap. 179 mm.) not far inferior to that of *Ocalientinus* (*Ser.*) *floridanus* (ap. 210 mm.), (5) indication of cement in the valleys, (6) rudiments of external and internal cingula.

Phyletic Position.—"The type of this Florida species belongs nearer to the elevated and compressed southwestern phylum of *Serridentinus serridens* and (?)*S. præcursor*[1] than to the blunted cone series which includes *S. productus* and *S. floridanus*, yet the elevation, compression, and serrate condition of the crests have not progressed so far as in the type of *S. serridens;* for example, the type tritoloph of M^2 in *S. serridens* exhibits six conelets, whereas the type tritoloph of *S. brewsterensis* exhibits only five conelets; the trefoil spur conelets of *S. serridens* are much more prominent than those of *S. brewsterensis*."

[1]Referred by Osborn (1935) to *Serbelodon*(?) *præcursor*.

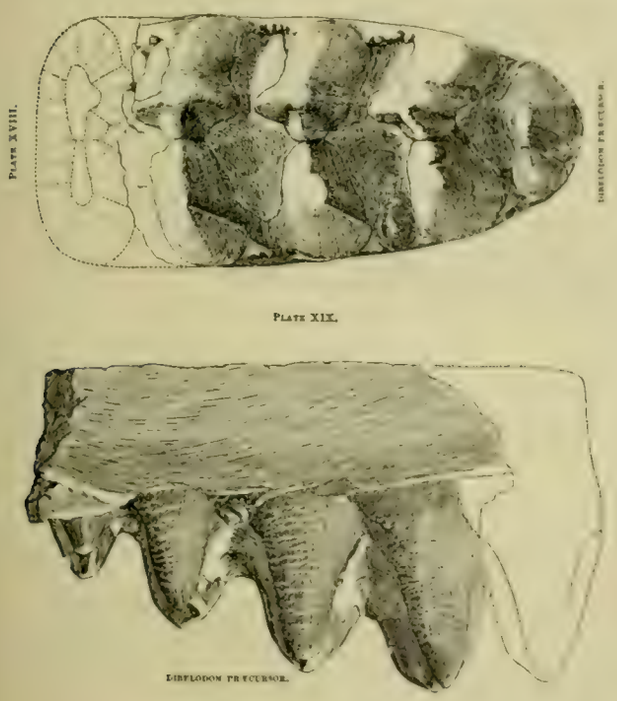
A third lower molar of the left side (Amer. Mus. 1875) from Brewster, Polk County, Florida, belonging to the Raymond Collection, was first referred by the present author to *Serridentinus brewsterensis;* it now appears to belong to *Ocalientinus* (*Serridentinus*) *bifoliatus*, under which specific name its description may be found.

Serbelodon(?) **præcursor** Cope, 1892, 1893

Figures 397–399

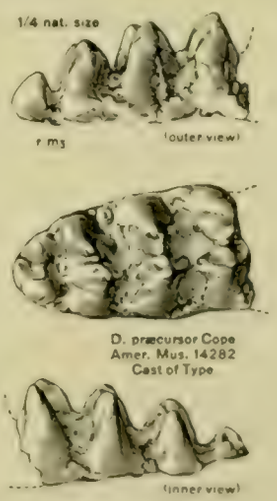
Upper Pliocene, Blanco formation, Mt. Blanco, Llano Estacado, Texas.

Osborn, 1935: The type of '*Dibelodon*' *præcursor* Cope was first erroneously referred by Osborn to *Serridentinus*; it resembles rather the corresponding molar of *Serbelodon barbourensis* (Fig. 408, p. 442 below). The resemblance is not specifically close, since Cope's type (Fig. 397) is five crested. Similar to Cope's type M³ of '*D.*' *præcursor* is Freudenberg's type of *Mastodon oligobunis* var. *felicis* (Fig. 516). The generic reference of both *præcursor* and *felicis* is still uncertain.



ORIGINAL TYPE FIGURE OF SERBELODON(?) PRÆCURSOR

Fig. 397. Original type figure of *Dibelodon præcursor* Cope, 1893, one-half natural size. After Cope, 1893.1, Pls. XVIII, XIX. From Mt. Blanco, Texas. Texas Geol. Surv. Coll., Austin, Texas. Cast Amer. Mus. 14282. A third superior molar of the right side, r.M³.



NEW TYPE FIGURE OF SERBELODON(?) PRÆCURSOR

Fig. 398. New type figure of third right superior molar, r.M³, of *Dibelodon præcursor* Cope, in the Geological Survey Collection, Austin, Texas. After cast of type (Amer. Mus. 14282). From Mt. Blanco, Texas. One-fourth natural size.

Blanco Epoch." Amer. Naturalist, 1892, Vol. XXVI, p. 1059 (name only). "A Preliminary Report on the Vertebrate Paleontology of the Llano Estacado." Fourth Ann. Rept. Geol. Surv. Texas for 1892 (Cope, 1893.1), pp. 64, 65. TYPE.—Posterior molar found in the side of the bluff from which Cope had excavated the jaw of the *Pliauchenia spatula*. "This molar tooth has lost its anterior cross-crest, but is otherwise perfect, and is unworn." Texas Geological Survey Collection, Austin, Texas. Cast Amer. Mus. 14282. HORIZON AND LOCALITY.—Blanco formation, Mt. Blanco, Llano Estacado, Texas; Upper Pliocene. TYPE FIGURE.—Cope, 1893.1, Pl. XVIII, . . . "last inferior [superior] true molar of the left [right] side, from above; anterior cross-crest supplied: natural size." Pl. XIX, . . . "tooth figured in Plate XVIII, from the inner [outer] side; natural size."

TYPE DESCRIPTION.—(Cope, 1893.1, p. 65): (1) The crown consists of four cross-crests and a very large heel, which has the constitution of the cross-crests, but is transversely contracted. (2) Crests remarkable for acute summits, more contracted transversely, shorter at the apex than in *T. serridens*, also more acute. (3) Accessory ridges, trefoils, on the external halves only, which would produce lobes on wear, while the internal halves of the crests are entirely simple. (4) Enamel smooth. (5) Considerable deposit of cementum between the crests. (6) Measurements: Length of last molar (anterior crest restored) 160 mm.; width at second crest 68 mm.; elevation of second crest 54 mm. (7) Approaching *M. americanus* in simplicity and acuteness of the crests.

Osborn, 1924: We observe in the type: (1) That one or two of the anterior crests are broken off; (2) that unlike *Serridentinus serridens* there is cement in the bottom of the

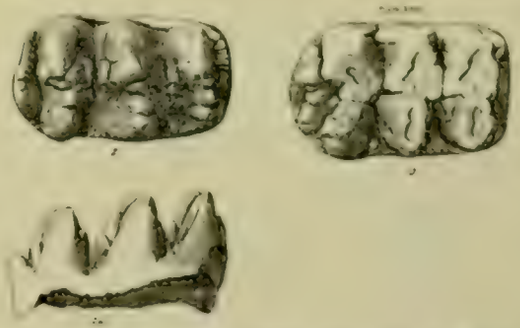


Fig. 399. The three referred teeth from the Blanco of Texas (Cope, 1893.1, Pl. XVII, figs. 2, 2a, and 3) were designated as, or referred by Cope to, his *Dibelodon tropicus* of Mexico, but are probably referable to his species *Dibelodon* [=*Serbelodon*(?)] *præcursor*.

In the Blanco formation Cope discovered his type of *Dibelodon præcursor*, a third superior molar of the right side, r.M³, as shown in the original and new type figures (Figs. 397 and 398). This tooth is doubtfully referable to the genus *Serbelodon*; its four and a half crested triangular form is readily distinguished from the five and a third crested oblong form of the type of *Cordillerion tropicus* (Fig. 513 of the present Memoir).

D. [*Dibelodon*] *præcursor* Cope, 1892, 1893. "The Fauna of the valleys; (3) that there are prominent *single* trefoils on the outer side of the crowns, whereas in the type of *Stegomastodon successor* from the Blanco formation there are double trefoils; (4) other simple teeth, perhaps referable to the species *Serridentinus præcursor*,[1] are found in the Cummins Collection of the Geological Survey of Texas; three of these are shown in Pl. XVII, figs. 2, 2a, 3, of Cope's Report (1893.1), as reproduced in figure 399 of the present Memoir.

[1]See footnote on page 430.

Combining the evidence afforded by Cope's type of *Dibelodon* [*Serbelodon* (?)] *præcursor* with that afforded by these referred teeth, we have some evidence of the presence in the Upper Pliocene of Texas of an apparently aberrant branch of the family Serridentidæ.

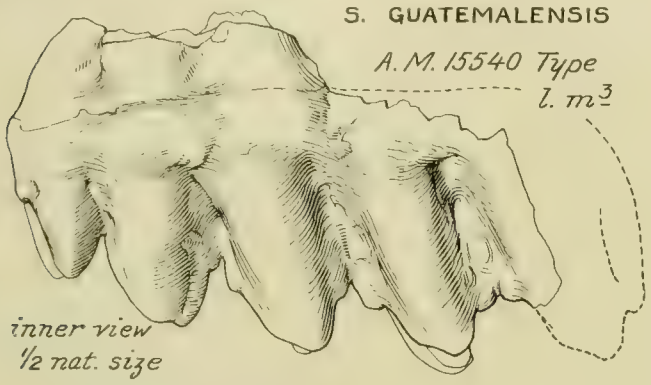


Fig. 400. Type third left superior molar, l.M^3, of *Serridentinus guatemalensis* Osborn, 1926 (Amer. Mus. 15540), one-half natural size. After Osborn, 1926.706, p. 12, fig. 10. Same molar as figure 401.

Internal aspect, showing posterior half of protoloph, the tritoloph, the tetartoloph, and the half-formed pentaloph. Observe the high, compressed internal cones and single trefoil conelets.

Serridentinus guatemalensis Osborn, 1926

Figures 400 and 401

Upper Pliocene, Chinautla, Guatemala, Central America.

The single type grinding tooth (Figs. 400, 401), consisting of the posterior portion of a third left superior molar, l.M^3, was a part of the Emil Mosonyi Collection purchased from Mr. Mosonyi in 1910, and represents the southernmost known distribution of *Serridentinus*. The type (Amer. Mus. 15540) is provisionally regarded as of Upper Pliocene age. While it resembles more nearly the Upper Pliocene *Ocalientinus* (*Ser.*) *obliquidens* of the Carolinas, it belongs rather in the high-crested series, the superior lophs being much taller than in the *O.* (*S.*) *obliquidens* paratype (Fig. 382, B1, B2). The number of ridge-crests is uncertain, but there are probably four plus as in *O.* (*S.*) *obliquidens*, the bilobed pentaloph being much taller than in *O.* (*S.*) *floridanus*.

Serridentinus guatemalensis Osborn, 1926. "Additional New Genera and Species of the Mastodontoid Proboscidea." Amer. Mus. Novitates, No. 238, November 30, 1926, p. 12. Type.—Posterior portion of a third left superior molar, l.M^3 (Amer. Mus. 15540). Horizon and Locality.—Upper Pliocene, Chinautla, Guatemala. Type Figure.—Osborn, *op. cit.*, 1926.706, p. 12, fig. 10.

Type Characters.—(1) Internal and external cones elevated, compressed, columnar. (2) Single trefoil conelets, anterior and posterior, on metaloph and tritoloph, no broad trefoil spurs as in *Ocalientinus* (*Ser.*) *floridanus* or *Ser. productus*. (3) Double cones on summits of meta-, trito-, and tetartolophs. (4) Pentaloph consisting of two low cones (elev. 45 mm.), compressed at summit. (5) Crown narrowing posteriorly but less rapidly than in *S. serridens cimarronis* or in *Serbelodon* (?) *præcursor*.

Fig. 401. New type figure of *Serridentinus guatemalensis* Osborn, 1926 (Amer. Mus. 15540), left third superior molar, l.M^3, one-half natural size. Same molar as figure 400.

External view (upper), showing the less elevated external cones.

Crown view (lower), showing the compressed double conelets on the summits of each cone; also the single trefoil conelets on the sides of the internal cones.

Comparative Measurements in Millimeters	*S. guatemalensis* Type	*Ocal.* (*Ser.*) *obliquidens* Ref.	*Ocal.* (*Ser.*) *floridanus* Metatype
Actual or estimated length of crown of M^3	170e	170e	210
Width of crown below tritoloph	83	84	107
Max. height of tritoloph, internal	77	67	82

The lophs are relatively taller in *Serridentinus guatemalensis* and in *Ocalientinus* (*Ser.*) *obliquidens* than in *O.* (*S.*) *floridanus;* the tritoloph region is much narrower, because of the absence of the prominent internal cingulum.

8. RECENTLY DESCRIBED GENERA (OCALIENTINUS, SERBELODON) AND SPECIES IN THE FRICK COLLECTION

This section is continued from pages 414–421, figures 374–385, in which the species *Ocalientinus* (*Ser.*) *republicanus* of Kansas, *O.* (*S.*) *floridanus*, *O.* (*S.*) *floridanus leidii*, and *O.* (*S.*) *bifoliatus* of Florida, also *O.* (*S.*) *obliquidens* of South Carolina are described. In the present section *O.* (*S.*) *floridanus* is compared with *O. ojocaliensis* of New Mexico and *O.* (*S.*) *republicanus* of Kansas.

Genus: **OCALIENTINUS** Frick, 1933

Genotypic species: *Ocalientinus ojocaliensis* Frick, 1933, from Santa Fé marls of New Mexico, Uppermost Miocene or Basal Pliocene.
Species referred by Osborn: *Serridentinus floridanus* Leidy, *S. floridanus leidii* Frick, *S. bifoliatus* Osborn, Lower Pliocene of Florida, *S. republicanus* Osborn, Lower Pliocene, Republican River of Kansas, *S. obliquidens* Osborn, Upper Pliocene of South Carolina, *Gomphotherium*(?) *emmonsi* Hay, Pliocene of North Carolina, and *S. florescens* Osborn, Pliocene of Mongolia.
Original reference: Bull. Amer. Mus. Nat. Hist., 1933, Vol. LIX, Art. IX, pp. 509, 576, and 579.

In the years 1924–1932, in the Santa Fé marls of New Mexico and the Ainsworth beds of Nebraska, the Frick collectors found the type of *Ocalientinus ojocaliensis* (F:A.M. 21294) and numerous other specimens on which Frick clearly established the new genus and species *Ocalientinus ojocaliensis*, named after the type locality, Ojo Caliente, New Mexico, characterizing (1933, pp. 576, 579) this genus as follows:

> "B. Symphysis Long – 'Longirostrines' Proper [Symphysis approximating 90-110% of the post symphysis—pouch length.] The great majority of the New Mexican remains seem referable to this more elongate-jawed subsection. The series includes several fine crania and mandibles. . . . Cranium Tall—Exampled by Species 4. *Ocalientinus ojocaliensis*, n.g. and sp. Type. Tall narrow skull and elongate jaws with peg-like incisors, F:A.M. 21294 (*Figs. 7 and 18*)."

Frick observed (*op. cit.*, p. 578) resemblances to *Serridentinus*. He kindly placed the rich *Ocalientinus* material in Osborn's hands for intensive measurement and comparison, resulting in the present full confirmation of *Ocalientinus* as a distinct genus and the establishment of its direct ancestral relationship to '*Serridentinus*' *republicanus* of Kansas and to '*S.*' *floridanus* of Florida, as clearly shown in the following descriptions and especially in the comparative figure (Fig. 403) of the third lower grinding teeth. To the generic characters assigned by Frick, the following may now be added: (1) Serridentines of large size belonging to group (A), with roundly blunted cones and conelets, not forming sharpened or elevated crests. (2) Inferior ridge-crests progressive from the tetartolophid to the pentalophid stage. (3) Prominent serrated ectotrefoils in inferior molars, corresponding with prominent serrated entotrefoils in superior molars (Fig. 404). (4) Both ecto- and entotrefoils progressively absorbing the adjacent conelets. (5) Superior and inferior ridge-crests sloping forward, slowly increasing in height.

Generic Characters (Osborn). (1) Mandible elongate (female 900 mm., male max. 1300 mm.), rostrum extremely narrow with deep superior longitudinal channel. (2) Superior tusks as in *Serridentinus*, with latero-inferior enamel band. (3) Inferior tusks without enamel, upcurved, relatively short, of the 'prod-tusker' or 'scaptobelodont' type. (4) Type ridge formula: M 3 $\frac{4}{4}$; type superior molars (F:A.M. 21294) relatively broad, M^3 177 mm. × 85 mm., index 48; M_3 (F:A.M. 21132) 198 mm. × 87 mm., index 44; M^3, index, breadth-length range, 43–52, average 48; lower molars, M_3, index, breadth-length range, 39–53, average 44; relative breadth of molars correlated with foreshortening of the cranium and heightening of the occiput. (5) Trefoil spurs dominant, florescent.

Under these generic distinctions, three specific stages may now be distinguished as follows:

	Mio-Pliocene *Ocalientinus ojocaliensis*				Lower Pliocene *Ocalientinus republicanus*				Lower Pliocene *Ocalientinus floridanus*			
	ap.	tr.	I.	Height of tritoloph	ap.	tr.	I.	Height of tritoloph	ap.	tr.	I.	Height of tritoloph
Average M^3	175	86	49	67					210	107	51	82
Average M_3	190	84	44	67	212	75	35	77	226	85	38	77
	M_3 with four ridge-crests, purely tetralophoid, rudimentary pentalophid.				M_3 with four ridge-crests, rudimentary cones representing pentalophid.				M_3 well developed with pentalophid added to four anterior ridge-crests.			

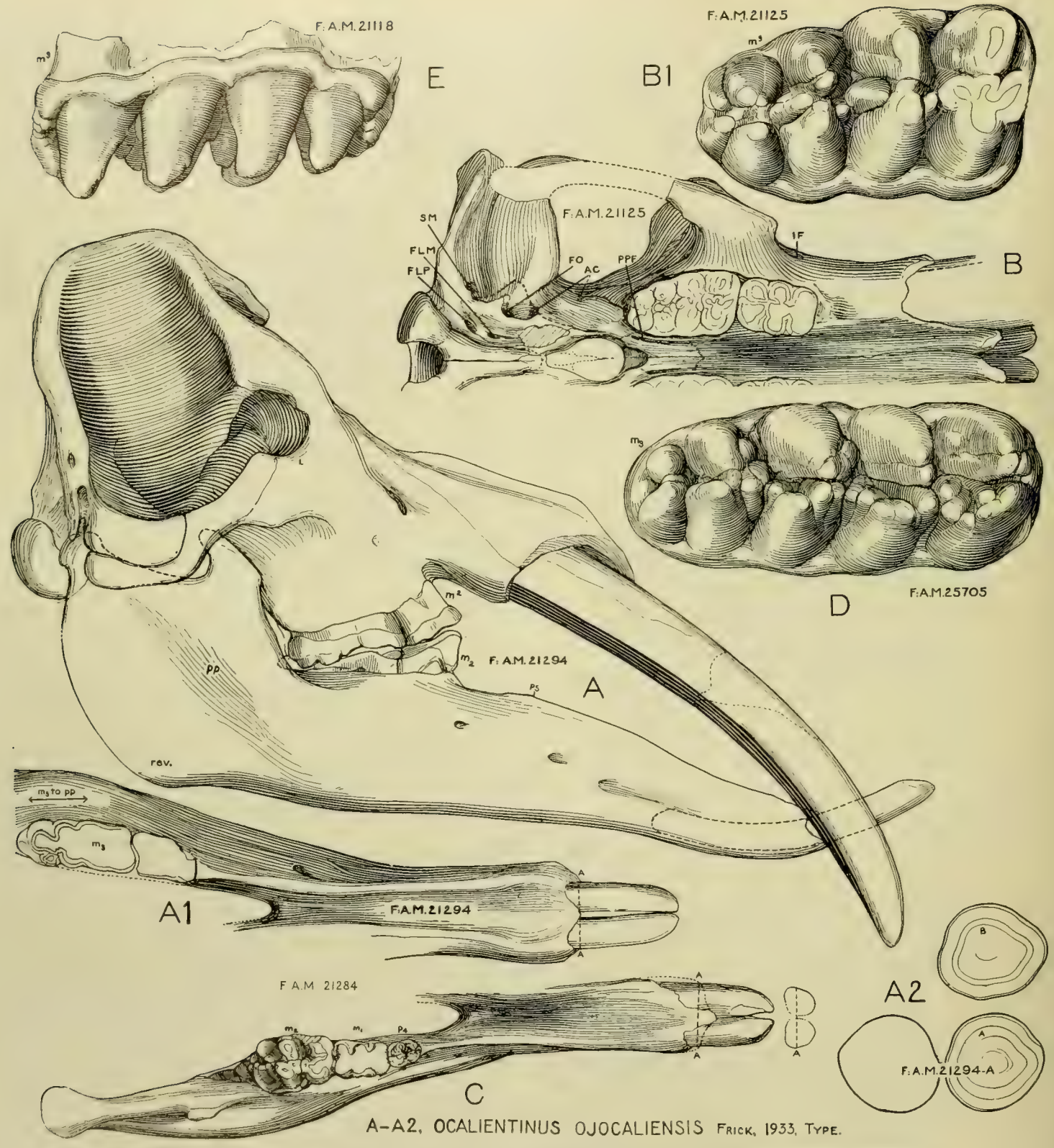


Fig. 402. LONG-JAWED SERRIDENTINE. OCALIENTINUS OJOCALIENSIS FRICK, 1933. TYPE AND REFERRED SPECIMENS

Original figures after Frick, 1933, Figs. 7, 12, 18, 19, 25A, 26

A, Type cranium and mandible (F:A.M. 21294), reversed. About one-seventh natural size.
A1, Crown view of type mandible (F:A.M. 21294). About one-seventh natural size.
A2, Transections of type inferior incisors (A—A). Two-fifths natural size.
B, Palatal view of referred cranium (F:A.M. 21125). One-eighth natural size.
B1, Crown view of referred r.M^3 (F:A.M. 21125). About two-fifths natural size.
C, Crown view of referred mandible (F:A.M. 21284). About one-seventh natural size.
D, Crown view of referred r.M_3 (F:A.M. 25705), ap. 208 mm. About two-fifths natural size.
E, External view of referred l.M^3 (F:A.M. 21118). About two-fifths natural size.

Correlation with India.—Of the above three species, *Ocalientinus ojocaliensis* is in an evolutionary stage closely similar to that of *Serridentinus basnotensis* (Fig. 415) of the Dhok Pathan of India, a fresh proof of correlation in geologic age of the Santa Fé marls of New Mexico with the lower levels of the Dhok Pathan of India (see Fig. 225, p. 279).

Ocalientinus ojocaliensis Frick, 1933

Figures 174–176, 276, 278, 279, 281, 402–405

Type from Ojo Caliente, New Mexico. Santa Fé marls (upper), Mio-Pliocene.

Ocalientinus ojocaliensis Frick, 1933. "New Remains of Trilophodont-Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, pp. 509, 576, 579. Type.—Skull and jaws with M^{2-3}, M_{2-3}, and tusks, also atlas, scapula, partial manus, pes, and series of vertebræ (F:A.M. 21294). Horizon and Locality.—From Ojo Caliente, New Mexico. Santa Fé marls (upper), Mio-Pliocene. Type Figure.—Frick, *op. cit.*, figs. 7 and 18.

Materials.—The type (F:A.M. 21294) of this species is a superb skull and jaws together with skeletal parts from Ojo Caliente, New Mexico, which is finely supported (Fig. 405) by the "neotype" (Frick) cranium (F:A.M. 21125) from southwest of Pojuaque Bluffs, New Mexico; also by the cranium (F:A.M. 21134) from Ojo Caliente, by the juvenile cranium (F:A.M. 21284), and by the mandibles (F:A.M. 21277, 21294 type, 21284, 21124, 21276). Superior and inferior tusks are finely preserved in F:A.M. 21294, 21284, and 21277, in addition to third superior and inferior grinding teeth in F:A.M. 21118, 21137 (Fig. 404), 21125, 21287, and 25711. In all, Frick field parties between 1924 and 1932 collected in the Santa Fé marls of New Mexico sixteen superior specimens largely on the upper levels, and several specimens in a similar stage of evolution in the Ainsworth region, Nebraska, which enabled Frick (1933, pp. 576, 579) to give a full characterization of this genus and species, also figures of the type and outstanding specimens which are partly reproduced in figures 402 to 405 of the present Memoir. Other catalogue numbers of referred specimens are as follows: F:A.M. 21123, 21136, 21281, 21294A, 21294B, 25720.

History.—The superb cranium (F:A.M. 21125) [first made a paratype (Frick, 1926, p. 161) of *Trilophodon (Serridentinus) pojoaquensis*] was subsequently (1933, p. 579) transferred to the new genus and species *Ocalientinus ojocaliensis* (*op. cit.*, 1933, p. 579) as follows:

F:A.M. 21294 Type.—Skull and jaws with $m\frac{2}{2}$-$m\frac{3}{3}$ and tusks; atlas, scapula, partial manus, pes, and series of vertebræ. M_3=((191)) mm. Type, *Figs. 7 and 18.* [Fig. 402 of present Memoir.]

F:A.M. 21125 Referred.—Fine skull with m^2-m^3 and tusk. M^3=172 mm. (This specimen in 1926, correctly characterized as to tall narrow cranium, etc., and as to probable elongation of symphysis.) Figured 1926, Figs. 1A and 27. Figured this paper, Figs. *8, 12, 23A and 26.* [Figs. 402B, B1, 405 of present Memoir.]

The above type and referred specimens, many admirably figured, enable us to fully determine the characters of this important form as a new Serridentine with smaller female mandibles of 900 mm. (F:A.M. 21124, 25705), ranging into 1000, 1100, 1200, and into the large male mandible of the type, 1300 mm. or 4 ft. 3 in., as compared in length with a large male mandible of *Serridentinus productus* (850 mm. or 2 ft. 9 in.); highly distinctive also is

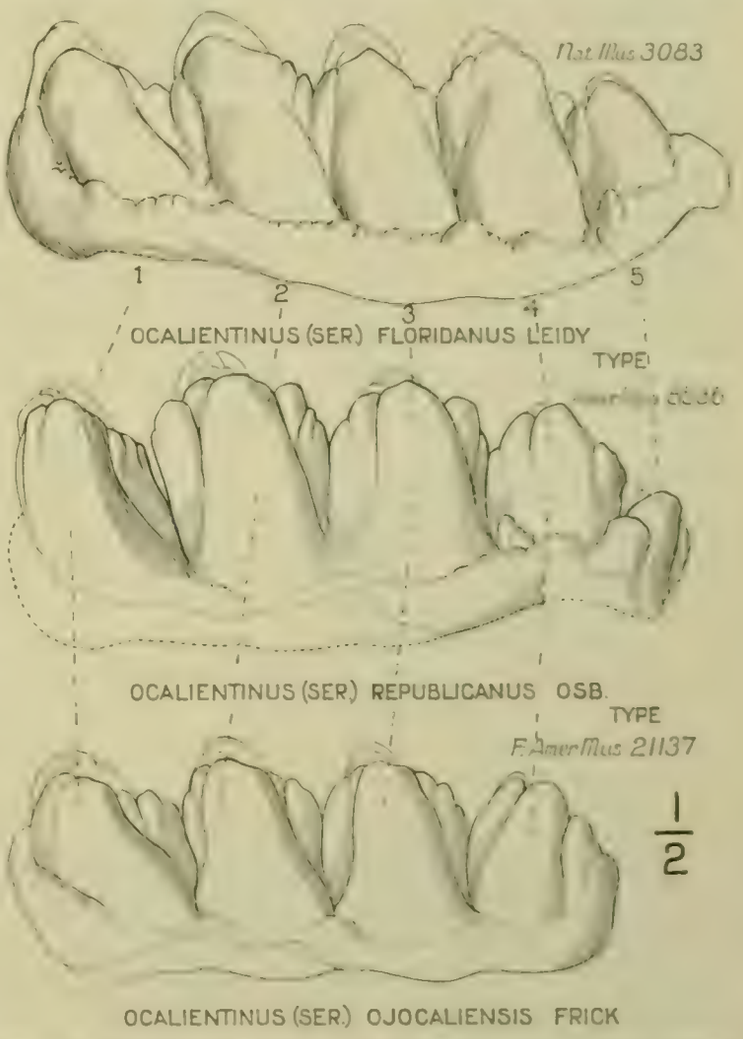


Fig. 403. Progressive Evolution of the Pentalophid in Ocalientinus
Left Third Inferior Molars, L.M_3

All figures one-half natural size. Compare figure 404

Ocalientinus (*Ser.*) *floridanus* Leidy, type (Nat. Mus. 3083), Lower Pliocene Alachua clays of Florida, with prominent pentalophid or fifth ridge-crest (5).

Ocalientinus (*Ser.*) *republicanus* Osborn, type (Amer. Mus. 8536), Republican River of Kansas, Lower Pliocene, with half-developed pentalophid or fifth ridge-crest (5).

Ocalientinus ojocaliensis Frick, ref. (F:A.M. 21137), west of Pojuaque Bluffs, New Mexico, Mio-Pliocene, with incipient pentalophid or fifth ridge-crest.

the long, deeply grooved superior channel of the symphysis. The tall narrow cranium, with constricted temporal fossæ and elevated occiput, contrasts with the relatively broad and low temporal fossæ of *Serridentinus productus* and *S. serridens*. The relationship to *Serridentinus*, however, is clearly demonstrated by the broadly serrated ectoconelet crests in the lower molars and entoconelet crests in the upper molars (Fig. 404). Clear distinction from both *S. productus* and *S. serridens* is seen in the reduction of the contiguous conelets above and below, a reduction which is carried a step further in the type of *Ocalientinus* (*Ser.*) *floridanus* (Figs. 379 and 403).

Separation from Trilophodon pojoaquensis.—Frick through his exploration (1924–1932) on the lower and higher levels of the Santa Fé marls, New Mexico, and at Ainsworth, Nebraska, discovered at least *thirty-seven* specimens of Serridentinæ, namely, *Ocalientinus ojocaliensis* 24, *S. productus* 8, *Serbelodon barbourensis* 5. Exploration during the same period (1924–1932) yielded only *eleven* specimens of *Trilophodon*, namely, *Trilophodon pojoaquensis* 4, *T. cruziensis* 3, *T. phippsi* 1, *T. osborni* 3.

Thus *Serridentinus* in the Santa Fé marls appears to be three times as frequent as *Trilophodon*, indicating that the *Trilophodon* range was northward of the *Serridentinus* range.

In the seven years which have elapsed since Frick described *Trilophodon* (*Serridentinus*) *pojoaquensis* (1926, p. 161, and 1933), we have learned to distinguish instantly and sharply between *Trilophodon* molars (Fig. 276A) with *large central conules, trefoils*, and *conelets* (F:A.M. 21115, type of *T. pojoaquensis*) and Serridentine (*Ocalientinus ojocaliensis*) molars (Fig. 276B, B1) with central conules, reduced central conelets, and large serrated entoconelets in the superior molars.

As one result of this very natural but regrettable confusion, the superb cranium (F:A.M. 21125, Fig. 405), originally referred to *Trilophodon pojoaquensis* (Frick, 1926), is now recognized (Frick, 1933) as a Serridentine clearly belonging to *Ocalientinus ojocaliensis*. It is fully described and illustrated below (pp. 437–439) as one of the most beautiful and important specimens of *Ocalientinus ojocaliensis*.

It appears certain, therefore, that *Ocalientinus ojocaliensis* represents a hitherto unrecognized generic phylum of Serridentinæ, specifically ancestral to *O.* (*S.*) *floridanus* (Fig. 379) and to *O.* (*S.*) *republicanus* (Fig. 375), both of Lower Pliocene age, whereas *Ocalientinus ojocaliensis* is of Upper Miocene to Lower Pliocene age.

Specific Characters of O. ojocaliensis.—(1) Clearly distinct both from *Serridentinus productus* and *S. serridens* by larger size, by height of the temporal fossæ and foreshortening of the cranium, by elongation of the ramus, by narrowed troughlike symphysis, by upcurved incisors. (2) Molars clearly distinguished from those of *S. productus* and *S. serridens* by larger size, by greater hypsodonty or elevation of the cones, by greater extension of the entotrefoil spurs on the superior molars and ectotrefoil spurs on the inferior molars. (3) Same trefoil spurs (Fig. 404) less prominent and elaborate than in the more progressive *O.* (*S.*) *floridanus* (Fig. 379) or in the somewhat less progressive *O.* (*S.*) *republicanus* (Fig. 375). (4) Superior and inferior molars relatively broader than in *O.* (*S.*) *floridanus* (index 51 superior, 38 inferior, cf. p. 411). (5) Molar crowns approaching those of *O.* (*S.*) *republicanus* (e.g., type A.M. 8536), M_3 length 212 mm., breadth 75 mm., index 35 (cf. Figs. 374, 375). (6) In M_3 median conelets of ectoloph present, also present in *O.* (*S.*) *republicanus* (Fig. 374A).

The comparative measurements and indices of the superior and inferior molars of the above three species are as below, arranged in what are known (1933) to be their ascending phylogenetic order:

	Superior Molars, M^3				Inferior Molars, M_3			
	Length	Breadth	Index	Height of tritoloph	Length	Breadth	Index	Height of tritoloph
Ocalientinus (*Serridentinus*) *floridanus*								
Type (Nat. Mus. 3083, cast Amer. Mus. 17725)					226	85	38	77
Metatype (Nat. Mus., cast Amer. Mus. 17726)	210	107	51	82				
Ocalientinus (*Serridentinus*) *republicanus*								
Type (Amer. Mus. 8536)					212	75	35	77
Ocalientinus ojocaliensis								
Type (F:A.M. 21294), male	177	85	48	40+	191e	75e		30+
Ref. (F:A.M. 25720)	183	91	50	45+				
Ref. (F:A.M. 21123)					190	91	48	40+
Ref. (F:A.M. 21137), female					177	80	45	69
Average of nine male and female specimens	175	86	49	67				
Average of twelve male and female specimens					190	84	44	67
Index calculated from average breadth and length			49				42	

Cautionary Note.—While it would appear from the above that these species are in ascending phylogenetic order, it is important to note as to measurements that: (1) The large single type specimens only of *Ocalientinus* (*Serridentinus*) *floridanus* and of *O.* (*S.*) *republicanus* are measured, whereas from nine to twelve type and referred specimens of *Ocalientinus ojocaliensis* are measured; (2) the average length and breadth and height of *O. ojocaliensis* rise in a decided manner into greater measurements in *O. republicanus* and still greater in *O. floridanus;* (3) the indices of the third superior molars of *O. ojocaliensis* indicate that *O. floridanus* increases in breadth, namely, from 48–49, to 51, while the third inferior molars decrease in breadth, namely, from 45 to 38; (4) the evolution of the trefoil crests is slowly progressive in both the superior and inferior molars from *O. ojocaliensis*, through *O. republicanus*, into *O. floridanus*, as shown in the relative figures; (5) the adjacent conelets degenerate as the ecto- and entotrefoil crests evolve, thus there are four mesoconelets in *O. ojocaliensis*, two in *O. republicanus*, and one in *O. floridanus;* the strong evolution of the ecto- and entotrefoils tend to absorb the adjacent conelets—a familiar process of "robbing Peter to pay Paul"; (6) in *O. ojocaliensis* M_3 is purely tetralophoid, in *O. republicanus* arises a very rudimentary pentalophid, in *O. floridanus* M_3 exhibits a strong pentalophid.

Ocalientinus ojocaliensis Frick, 1933[1].—"The right side of the unusually well preserved skull (Amer. Mus. 21125 [Fig. 405], . . .) reveals the remarkable height of the posterior cranial area, foreshortening of the cranium proper, and prolongation of the premaxillary-anterior-maxillary area in this form. Double alveoli evince the recent presence of m^1; m^2 is considerably worn; the first crest of m^3 slightly worn. The short nasals, the short true palate, the auditory conduit formed of the post-glenoid and post-tympanic processes of the squamosal and adjoining ex-occipital plate, the short and deeply concave glenoid surface, the short alisphenoid canal, the prominent postorbital region of the frontal and the various foramina (optical, double infra-orbital, lacerum-medium and posterium and condylar, the canal of internal carotid artery, and the stylomastoid foramen) are all of general characteristic proboscidean type. The left side of the specimen is disintegrated and the following areas are either broken or missing: a portion of the median parietal-frontal area; the outer half of the left tusk (the enamel band being indistinguishable) and the right tusk; the postero-extremity of the premaxilla forming the elevated anterior border of the olfactory fossa; a portion of the malar including that which usually projects below the glenoid fossa; the presumably elongate bulla and the prominent pterygoid wings of the alisphenoid. The specimen is further described in the discussion below." See page 439 of the present Memoir.

Ocalientinus ojocaliensis Mandible[2].—"The left ramus contains the roots of p_4, m_1, m_2 erupting, the right ramus m_1 and m_2 erupting, and (within the same matrix and) in definite association the p^4-m^2 of the right side (Amer. Mus. 21124, Fig. 13 [Fig. 175]). The symphysis is somewhat crushed; it is more elongate than in *T.* (*S.*) *productus* (see below); the broken extremity discloses the bases of similar tusks. The unerupted m_2 [m_3] lies in the alveolar pouch below and just anterior to the mandibular condyle, the tooth axis directed postero-externally and antero-inwardly (through the angulation of the base of the vertical ramus and the alveolar border), the tooth tilted inwardly and forming a wide outwardly opening angle with m^1 (see Fig. 13 [Fig. 175], page 133)."

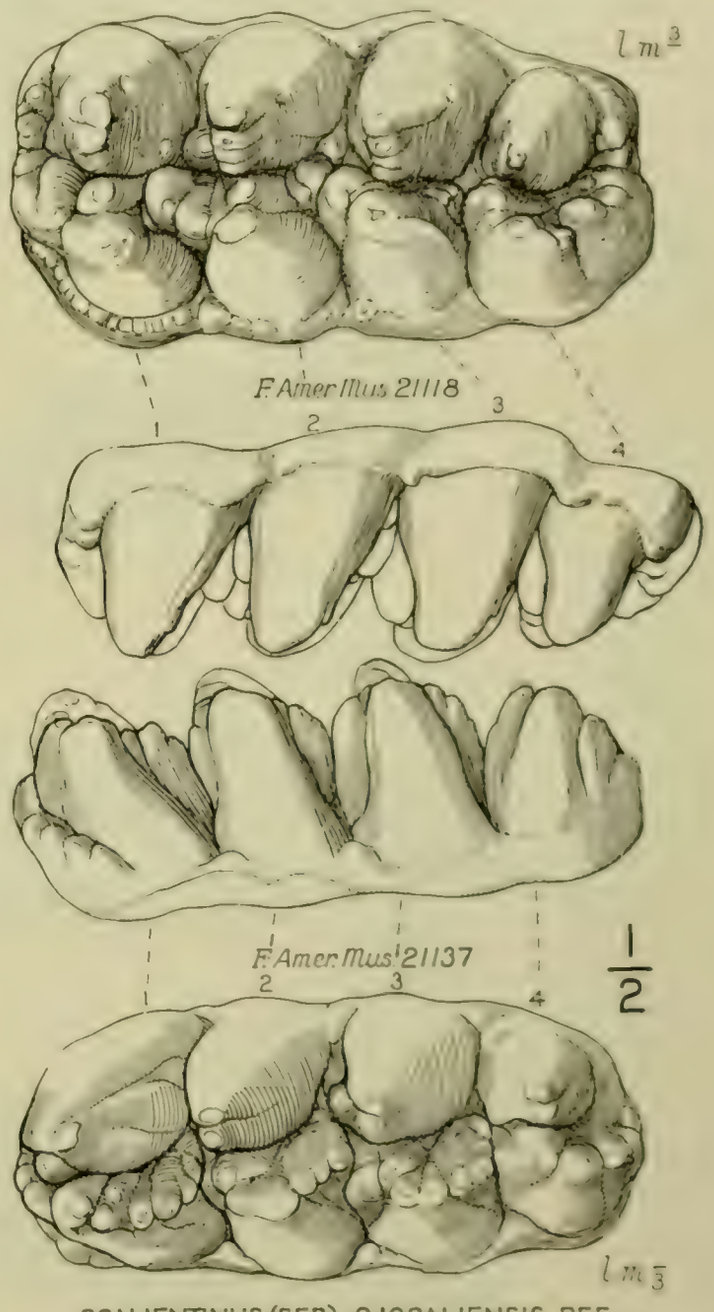


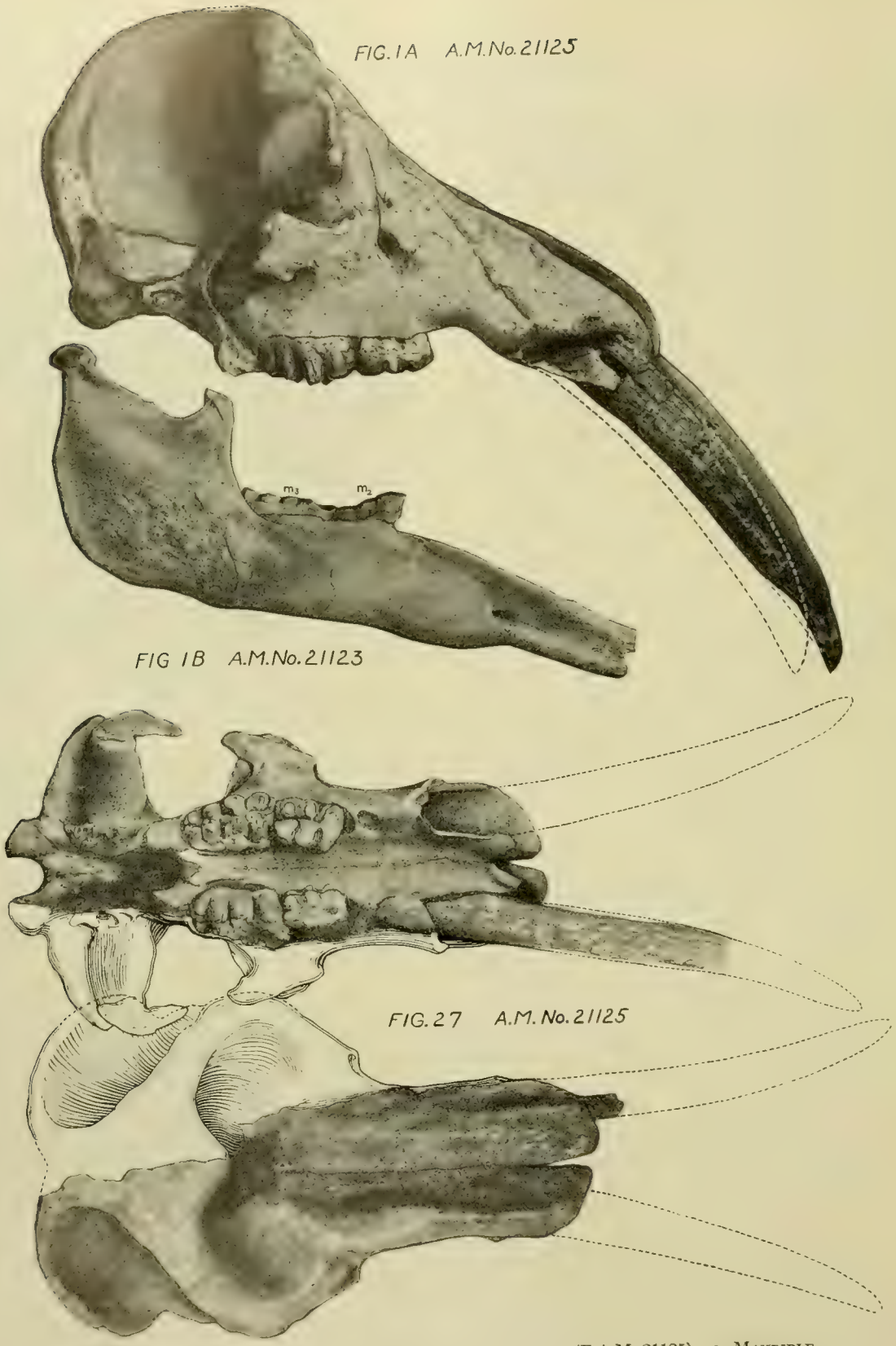
Fig. 404. Third Superior and Inferior Molars of Ocalientinus ojocaliensis Frick

All figures one-half natural size. Drawings by H. De Berard
Compare figure 403

Observe the following: (1) Four ridge-crested or tetralophoid crowns of $l.M^3$, $l.M_3$ as characteristic of this species; (2) prominent serrated trefoil spurs from *entoconelets* in $l.M^3$, from *ectoconelets* in $l.M_3$, a Serridentinæ subfamily character linking this species with '*Serridentinus*' *floridanus* and '*S.*' *republicanus*, as shown in figure 403.

[1]This description applies to the *Ocalientinus ojocaliensis* cranium and jaw shown in figure 405 (see Frick, 1926.1, p. 162).

[2]Immature mandible, doubtfully referred by Frick (1926.1, p. 165) to *Trilophodon* (*Serridentinus*) *pojoaquensis*, by Osborn to *Ocalientinus ojocaliensis*.



CRANIUM OF OCALIENTINUS OJOCALIENSIS IN THREE ASPECTS (F:A.M. 21125) AND MANDIBLE OF ANOTHER INDIVIDUAL (F:A.M. 21123)

Fig. 405. Skull (F:A.M. 21125) and jaws (F:A.M. 21123) originally figured and described by Frick (1926, figs. 1 A–B and 27, p. 161) as paratypes of *Trilophodon pojoaquensis*. From the Santa Fé marls, New Mexico.

(Upper) Figs. 1 A-B. "Lateral view teeth and cranium × 1/10 (premaxillary areas somewhat distorted). (A) Skull, Amer. Mus. 21125 (see Fig. 27). (B) Mandible [Amer. Mus. 21123] of slightly larger individual containing m_2-m_3, and bases of tusks. Symphysis somewhat crushed inferior to mental foramen. . . . (See Figs. 7B and 13 in part [=Figs. 174 and 175 of the present Memoir])."

(Lower) Fig. 27. Skull (Amer. Mus. 21125), dorsal and inferior views, one-tenth natural size. (See Fig. 1A.)

Referred Ocalientinus ojocaliensis Skulls, Jaws, and Teeth [originally referred by Frick, 1926, to Trilophodon (Ser.) pojoaquensis]

(1) Amer. Mus. 21122A (not figured). M_3 of great size, surface of crown missing.

(2) Amer. Mus. 21125, Figs. 1A and 27 (=Fig. 405 of the present Memoir). Well-preserved skull containing M^2, M^3 (slightly worn) of both sides, and tusk of left side of jaw. Pojuaque area.

(3) Amer. Mus. 21123, Figs. 1B, 7B and (in part) 13 (=Figs. 174, 175, and 405 of the present Memoir). Mandible containing M_2, M_3 greatly worn, anterior end of symphysis missing.

(4) Amer. Mus. 21118B. Partial ramus of right mandible containing M_2 and M_3 (broken). Not figured.

(5) Amer. Mus. 21118, Fig. 22B (=Fig. 402E, 404 of the present Memoir). Palate with M^2 (broken) and M^3 (unworn) of both sides of jaw.

(6) Amer. Mus. 21118A (not figured). M_3 (unworn) in fragment.

(7) Amer. Mus. 21126 (not figured). Right femur 810 mm.

Immature Material of Ocalientinus ojocaliensis

(8) Amer. Mus. 21124, Fig. 13 (in part) (=Fig. 175 of the present Memoir). Mandible containing P_4 (roots), M_1 and M_2 (erupting) of left side and M_1, M_2 (erupting) of right side, anterior end of symphysis broken, and associated P^4-M^2 of right side.

(9) Amer. Mus. 21124D, Fig. 19C (=Fig. 176 of the present Memoir). P^4 (broken).

(10) Amer. Mus. 21124C, Fig. 19B (=Fig. 176 of the present Memoir). P^3 (?) fragment.

(11) Amer. Mus. 21124E. Dp^4 right (moderately worn).

Skull and Jaws, Figure 405, and Other Specimens, with Certain Text omissions and Figure References

Ocalientinus ojocaliensis[1].—(See Frick, 1926.1, pp. 162–164): "The right side of the paratype skull (Amer. Mus. 21125, 1A and 27 [Fig. 405]) is beautifully preserved, and displays very completely the characters of the particular specimen, a mature individual with m^1 considerably worn and m^2 coming into wear. The two molars are apparently nearly proportionate in size to those of a large mandible [Amer. Mus. 21123] representing a somewhat older individual (Fig. [405] 1B). The diameters of the m^3 and tusk of the paratype are some 15 per cent less than in the type specimen. . . . In the paratype skull the distance between the infra-orbital foramen and the anterior edge of the premaxilla is approximately the same as that between the infra-orbital foramen and the external auditory meatus."

"The specimen is particularly remarkable in the height of the posterior cranial area, an area but seldom found in an uncrushed condition, and in the foreshortening of the cranium proper. The contrast, thus, of the great elevation (through dorsoventral expansion) and anteroposterior contraction (through anteroposterior 'telescoping' of the bones) of the cranium proper, with the marked prolongation of the premaxillary-anterior-maxillary area, is very striking. . . . A section cut out of the temporal border witnesses a parallel separation of the cancellous tissue and development of air-cells typical of the adult cranium of the elephant. The foreshortening of the cranium proper is very noticeable in the zygoma and basi-cranial area. This foreshortening is also seen in consideration of the position of the anterior border of the orbit, suborbital foramen, anterior narial opening, and anterior edge of the alveolar border, which, placed much as usual relative to one another, have the appearance of all having been shoved far backward. The constriction of the lofty roof of the cranium through the development of great fossorial areas for attachment of the necessarily powerful muscles of the neck and of the elongated jaw and trunk is carried to an extreme unnoticed heretofore. With the development of the first series of muscles, those of the neck, is correlated the prominent dorsoventrally flattened and transversely concave bed-plate of the exoccipital-supra-occipital region; with that of the masseteric muscles, the deep transverse constriction of the disproportionately foreshortened and dorsoventrally elongated mid-cranial region; and with the probably powerful trunk, the wide gutter of the anteroposteriorly elongate narial-premaxillary trough which extends diagonally forward and downward from below the strong supra-orbital arches and anterior border of the large olfactory fossa and directly forward of the powerful maxillary-dentary battery."

Lower Jaws.—[1] "The last molars of the large mandible (Amer. Mus. 21123 Figs. 1B [Fig. 405] and 13 [Fig. 175], in part) are so closely proportionate to the last molars of the paratype skull (Amer. Mus. 21125, Figs. 1A and 27 [Fig. 405]) that it is believed that the two specimens represent individuals of approximately the same size, the worn teeth of the mandible, however, showing that the latter was considerably the more aged. [2] A [referred] immature mandible (Amer. Mus. 21124, Fig. 13 [Fig. 175], in part) indicates an individual that at maturity would apparently measure greater than the above specimen (Amer. Mus. 21123). . . . [3] It remains in doubt (as observed above) whether the palate (Amer. Mus. 21118), an m_3 (Amer. Mus. 21118A), and perhaps this immature mandible (Amer. Mus. 21124) may be correctly referred to the new species. The molars of these specimens, particularly as seen in the unworn [right and left] m^3s of the palate, differ from the type and paratype specimens in the greater length relative to the width and resultingly less crowded condition of the main tubercles.

Comparative Measurements

Skull, Mandible, Dentition Compare Frick, 1926, pp. 156, 157	*Ocalientinus ojocaliensis*	*Trilophodon osborni*
Skull (F:A.M. 21125):		
Condyle to incisive border	920	915–965
Height of cranium at occipital plate	580	508e
Breadth of cranium at occipital plate	(640)	710e
Jaw (F:A.M. 21123):		
Condyle to incisive border	1050 (to break)	1346
Length, third inferior molar, M_3	189	190[196]
Length, second inferior molar, M_2	[126]	

Femur.—"A large femur tentatively referred to this species measures 810 mm., versus 700 mm. of the femur of the mounted Texan skeleton of *T.* (*S.*) *cimarronis*, 1080 mm. of the longer-limbed Warren mastodon, and 1230 mm. of the Indiana skeleton of *E. columbi* [*Parelephas jeffersonii*]."

[1]See footnote 1 on page 437.

SUPPLEMENTARY OBSERVATIONS BY FRICK (1933) AND BY SIMPSON (1930)

SERRIDENTINUS SERRIDENS COPE IN THE FRICK COLLECTION (1929)

Supplementing the full description above of *Serridentinus serridens* is the immature skull and mandible (F:A.M. 23340) collected in the year 1929, probably from the Clarendon horizon level of northern Texas. Compared with the type (cast Amer. Mus. 14297) and referred specimen (Amer. Mus. 10673), the second molar measurements are as follows:

	M^2			M_2		
Serridentinus serridens	ap.	tr.	I.	ap.	tr.	I.
Cope's type (cast A. M. 14297)	130	80	61			
Referred: Amer. Mus. 10673	137e	90	66e	139	69	50

SERRIDENTINUS PRODUCTUS COPE IN THE FRICK COLLECTON (1924–1931)

It is important to add, supplementing the full description of Cope's type of *Serridentinus productus* (Nat. Mus. 2346, cast Amer. Mus. 14383) and Frick's neotype (F:A.M. 21111) from the Santa Fé marls, seven other specimens from the marls, one specimen from the Clarendon of Texas, and one from the Pawnee Creek, Colorado, area. The principal measurements and indices are as below.

MANDIBLE.—The length of the mandible of *Serridentinus productus* rises from 600 mm. (F:A.M. 21119) to 850 mm. (F:A.M. 21283), to 910 mm. in the large Frick neotype (F:A.M. 21111); thus the largest *S. productus* mandible (910 mm.) is the same size as the smallest *Ocalientinus ojocaliensis* mandible (900 mm.), probably female (F:A.M. 21124); in turn, the largest *S. productus* mandible (910 mm.) is inferior in size to the largest (980 mm.) *Serbelodon barbourensis* type mandible (F:A.M. 25730).

SERRIDENTINUS FLORIDANUS[1] AND S. BREWSTERENSIS

Supplementary observations by George Gaylord Simpson in his "Tertiary Land Mammals of Florida," 1930, pp. 198–203, yield three principal results: (1) The rarity or absence in the Pliocene fauna of Florida of mastodonts referable to *Trilophodon*, *Rhynchotherium*, or *Stegomastodon;* (2) the presence of *Pliomastodon* and of two distinct specific stages of *Serridentinus* in the Bone Valley and Alachua formations, namely, (a) *Serridentinus floridanus*[1] a successor in evolution to the *S. republicanus*[1] of the Lower Pliocene of Kansas, (b) *S. brewsterensis* comparable to (?)*S. præcursor*[2] of the Blanco or *S. anguirivalis* of the Snake Creek of Nebraska. Also (c) *Trilophodon simplicidens*, a small and simple stage found in the Bone Valley without known parallel thus far discovered in America or Europe. *S. floridanus* ref. rare in the Bone Valley and clearly distinguishable from the prevailing Bone Valley species *S. brewsterensis.*

Serridentinus floridanus[1] Leidy, 1886

Abundant in the Alachua clays

Third inferior molars, M_3, relatively large and narrow, length 215–225 mm., breadth about 85 mm.; pentalophid relatively constant and well developed, narrow and usually without central conules; hexalophid rudimentary, variable, consisting usually of one small cone—rudimentary in the type, relatively strong in some referred specimens; ridge-crest conelets generally double, trefoil-crest conelets single or double; ridge-crests backwardly inclined from the vertical. Measurements of M_3 190×95 mm., index 50, to 205×105 mm., index 51; difference in width between proto- and tetartolophids relatively slight, pentalophid variably developed, with from two to five conelets. Altogether a rather progressive species, certainly not more progressive than *S. republicanus* of the Lower Pliocene of Kansas; the latter similar to *S. floridanus* in size but rudimentary pentalophid in M_3 more complex and trefoil conelets more numerous.

Serridentinus brewsterensis Osborn, 1926

Prevailing in the Bone Valley formation

Distinguished from *Serridentinus floridanus*[1] by its slightly smaller size, M^3 measuring 179×87 mm., index 49, by the absence of a pentaloph, and by relatively small and narrow tetartoloph. In several third lower molars, M_3, from the Brewster type locality, hexalophid absent, pentalophid small and consisting of four closely appressed conelets rather than of two subequal and more widely spaced cones as in *S. floridanus.* This species, *S. brewsterensis*, appears to be close to several western species, such as *S. præcursor*[2] Cope, 1892, 1893, of Mt. Blanco, or *S. anguirivalis* of the Snake Creek of western Nebraska, distinguished by higher and sharper crests.

Serridentinus productus				Lengthof Mandible	M^3 ap.	M^3 tr.	M^3 I.	M_3 ap.	M_3 tr.	M_3 I.
1875	Nat. Mus. 2346 (Type)	Santa Fé area, N.M.	Mandible					164	76	46
1924	F:A.M. 21111 (Neotype)	Santa Fé area, N.M.	Mandible	910				153	69	45
1899	Amer. Mus. 10582	Clarendon beds, Texas	Skull, jaws, large part of skeleton	905	142	85	60	163	76	47
1924	F:A.M. 21119	Santa Fé area, N.M.	Portion of rt. ramus	600a[3]				136e	58	43e
1929	F:A.M. 21293	Ojo Caliente, N.M.	Half of skull and mandible	700a	146	61	42	146	59	40
1928	F:A.M. 21283	Pojuaque Bluffs, N.M.	Mandible	850(s)[3]				175	68	39
1927	F:A.M. 21279	Lower Pojuaque Bluffs, N.M.	Skull and mandible		154	83	54	165	69	42
1928	F:A.M. 21280	Lower Pojuaque Bluffs, N.M.	Mandible fragment					187	82	44
1931	F:A.M. 21128	Santa Cruz, N.M.	Mandible					191	83	43
1930	F:A.M. 21297	San Ildefonso, N.M.	Palate		146	85	58			
1931	F:A.M. 23336	Pawnee Creek, Colorado	R.M_3					172	72	42

[1]Transferred by Osborn (1934) to the genus *Ocalientinus.*
[2]Referred by Osborn (1935) to *Serbelodon*(?) *præcursor.*
[3]In column of mandibular lengths, "a" indicates approximate, "s" to end of symphysis only.

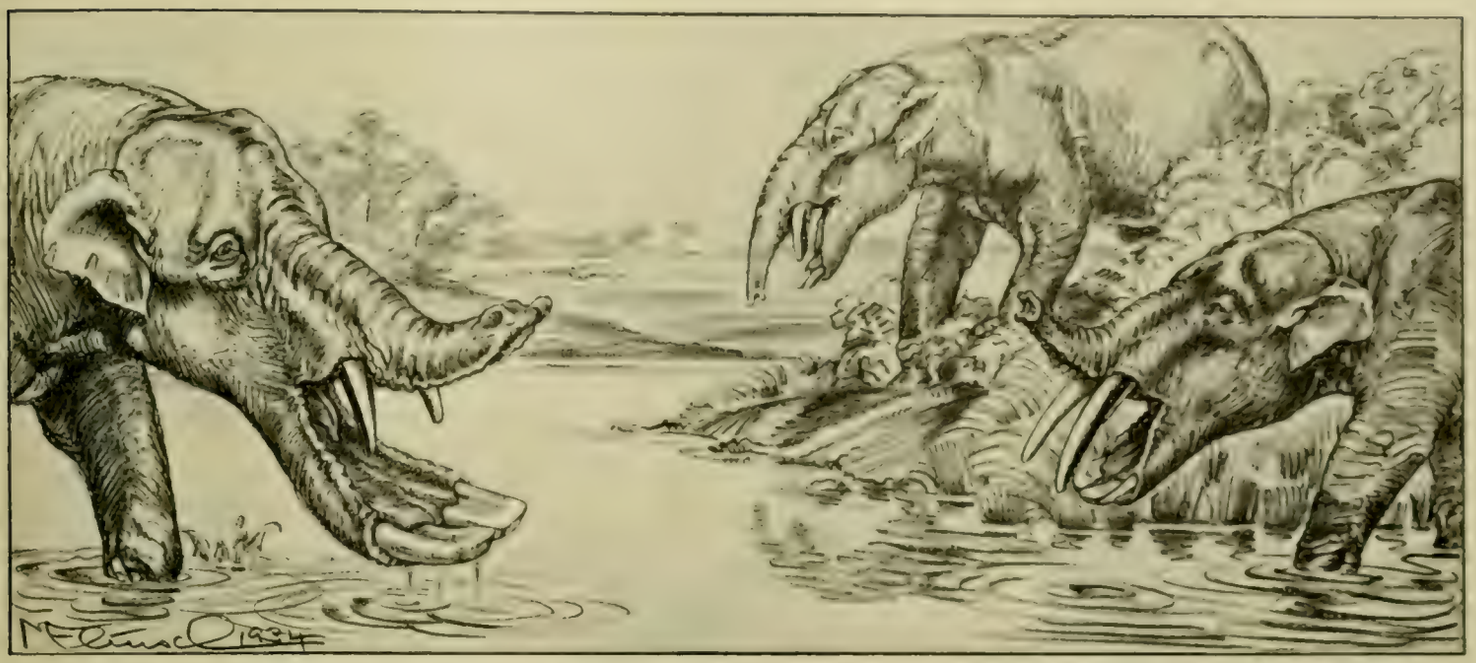


Fig. 406. Restorations (1934) by Margret Flinsch, under the direction of Henry Fairfield Osborn
(Right lower) *Serbelodon barbourensis*, and (left) *S. burnhami*, both one twenty-fifth natural size; (right upper) *Trobelodon taoensis*, one-fiftieth natural size.

9. TWO BLUNT SERRIDENTINE SHOVEL-TUSKERS (SERBELODON AND TROBELODON)

In the year 1932, near Ainsworth, Nebraska (Figs. 273, 274), Frick's party discovered a new short-jawed 'sub-shovel-tusker' which he named *Serbelodon*, in reference to the serrate character of the ectoconelets (below) and entoconelets (above). In 1930 he discovered in the Santa Fé marls of New Mexico another kind of 'shovel-tusker,' with smaller incisive "shovels," a shortened cranium, and serrated molars, which he named *Trobelodon taoensis*, in reference to the ancient pueblo of Taos near which it was found. These two 'sub-shovel-tuskers' are clearly distinguished from *Platybelodon* by the *total absence of the dentinal rod-cones* in the lower incisive tusks; they thus represent two new and distinct lines of descent of short-jawed mastodonts with enlarged sub-shovel-shaped incisors adapted to digging and uprooting probably in forest soils.

Trobelodon Frick, 1933, p. 580

Cranium probably short; third superior molars extremely short with only three ridge-crests; trefoils extending from entoconelets in the three-crested superior molars (Fig. 412, B1), from the ectoconelets in the four-plus-crested third inferior molars (Fig. 412, A3). Tusks moderately heavy, biconvex, pointed (Fig. 412, A, A1–A4).

Serbelodon Frick, 1933, p. 594

Cranium probably more elongate; third superior and inferior molars (Fig. 408 C, C1, A) four crested, relatively long and narrow with entoconelet spurs above (C1) and ectoconelet spurs below (A). Tusks elongate, spatulate, concavo-convex (*S. barbourensis*, Fig. 408 A1, E), greatly enlarged, extremely heavy (*S. burnhami*, Fig. 409B). Observe progressive evolution of the shortened symphysis (*S. barbourensis*, Fig. 409A, *S. burnhami*, Fig. 409 B), the latter much more massive.

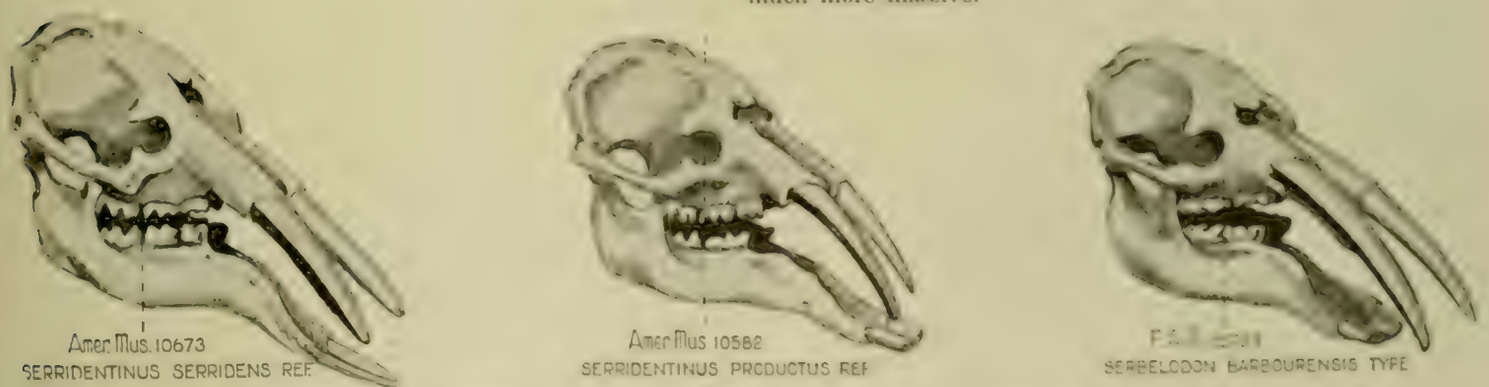


Fig. 407. Adaptive Radiation of Three Types of Serridentine Crania and Jaws, Tusks, and Grinding Teeth (cf. Fig. 408).
Serridentinus serridens, with sharp-crested molars, elongated and pointed lower incisive tusks; adapted to a dry climate and penetration of a hard soil.
Serridentinus productus, with blunt-crested molars and broadened tusks, adapted to a semi-humid climate and penetration of a less resistant soil.
Serbelodon barbourensis, adapted to a humid climate and softer soil, with penetrating broadened shovel-tusks, no dentinal rod-cones; ancestral to *S. burnhami*.

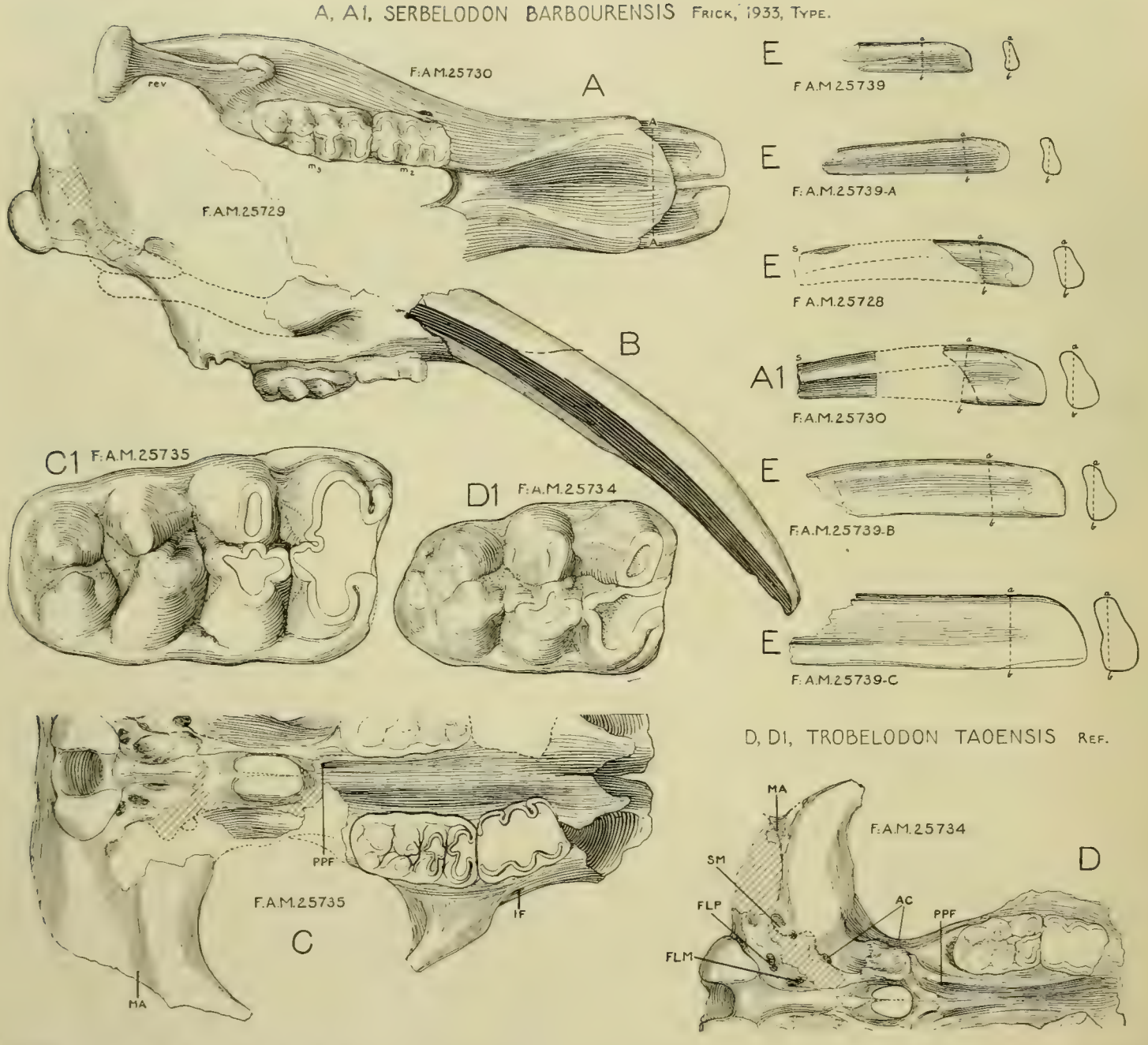


Fig. 408. (A, B–C1, E) Short-jawed Serbelodon barbourensis, (D, D1) Trobelodon taoensis, Genotype and Referred, Ainsworth, Nebraska After Frick, 1933, Figs. 12C, 13, 14, 16, 27. Compare figures 397, 398, *Serbelodon*(?) *præcursor* Cope, type, and figure 411 B, B1, *Trobelodon taoensis* ref.

A, *Serbelodon barbourensis* Frick. Genotype mandible (F:A.M. 25730). One-seventh to one-eighth natural size. Left M_3, ap. 170 mm., tr. 77 mm., index 45. After Frick, 1933, fig. 16.

A1, Left inferior incisor of same (F:A.M. 25730).

B, Imperfect cranium and tusks of referred specimen (F:A.M. 25729). One-seventh to one-eighth natural size. After Frick, 1933, fig. 27.

C, Palate of referred cranium (F:A.M. 25735). One-seventh to one-eighth natural size. After Frick, 1933, fig. 12C.

C1, Enlarged view of $l.M^3$ (F:A.M. 25735), ap. 175 mm., tr. 98 mm., index 56. About two-fifths natural size.

E, Referred left inferior incisive tusks in five different growth stages. Between one-seventh and one-eighth natural size. After Frick, 1933,fig. 14.

D, *Trobelodon taoensis* Frick. Referred cranium (F:A.M. 25734), about two-fifteenths natural size. After Frick, 1933, fig. 12C. D1, Third right superior molar of same, ap. 123 mm., tr. 80 mm., index 65. Two-fifths natural size. Repeated in figure 411, B, B1.

Genus: **SERBELODON** Frick, 1933

Genotypic species: *Serbelodon barbourensis* Frick, 1933, pp. 592, 594.
Original reference: Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, pp. 592, 594.

In the year 1932, in the 'Christmas quarry' near Ainsworth, Brown County, Nebraska, were found the type of *Serbelodon* (F:A.M. 25730) and several other specimens, on which Frick (1933, p. 594) clearly established the new genus and species *Serbelodon barbourensis*, and characterized this new form as follows:

> Generic Characters. —"A. Symphysis Moderate—'Sublongirostrines' . . . 'Sub-shovel-tuskers'—mandibular symphysis heavy and short, inferior incisors short, heavy, spatulate, superior tusks with strong enamel band, superior tusks worn deeply against opposed pair, last molars noticeably short."

Frick was first impressed with the flattened incisors of the six (Fig. 408 A1, E) specimens of *Serbelodon barbourensis* as analogous (F:A.M. 25739C) to the extremity of an incisor referred to *Amebelodon fricki*. The *A. fricki* incisor is of far greater length, namely, 1144 mm., as compared with the incisor of the *S. barbourensis* type (F:A.M. 25730) which measures only 350e mm. A similar contrast in length distinguishes the mandible of *S. barbourensis* (total length 980 mm.) from the type mandible of *A. fricki* (total length 1475 mm.).

> Generic Characters.—The disparity both in inferior incisor length and in jaw length demonstrates: (1) That *Serbelodon* is a genus and phylum remotely *analogous* to the typical shovel-tusker *Amebelodon* Barbour,—the "sub-shovel-tusker" adaptation represents an ancestral rather than a true genetic relationship, (2) the true genetic relationship appears to be to *Serridentinus* owing to the serridentine trefoils of the grinding teeth (Fig. 408 C1), but distinguished by the absence of serrated borders; (3) the mandible of *Serbelodon* differs very widely from the elongated mandible of *Ocalientinus* (Fig. 402 A1, C) as well as from that of *Serridentinus productus* (Fig. 369B) in its extreme abbreviation and broadening (Fig. 408 A); (4) the inferior incisors of *Serbelodon* (Fig. 408 A1, E) are relatively short and broad, correlated with the extremely short and relatively broadened symphyseal rostrum; (5) the total jaw length (980 mm.) equals that of *S. productus*; (6) the symphysis and flattened incisors, typified by dentinal laminæ, are analogous to those of an abbreviated *Amebelodon* (*Trilophodon*) *paladentatus* or *Amebelodon fricki*.

Molars.—The subfamily relationship of the genus *Serbelodon* to the Serridentinæ is demonstrated in the widely expanded entotrefoils of the superior molars (Fig. 408 C, C1) and the ectotrefoils of the inferior molars (Fig. 408 A). In brief, this appears to be a Serridentine shovel-tusker with a short or medilongirostral mandibular ramus—a new and most interesting adaptation. The jaw lengths and molar indices are as follows:

Serbelodon barbourensis				Length of Mandible	M^3			M_3		
					ap.	tr.	I.	ap.	tr.	I.
1932	F:A.M. 25730 (Type)	Ainsworth, Neb.	Mandible	980				170	77	45
1932	F:A.M. 25728	Ainsworth, Neb.	Mandible	870				173	70	40
1932	F:A.M. 25729	Ainsworth, Neb.	Skull		141	88	63			
1932	F:A.M. 25735	Ainsworth, Neb.	Skull		176	98	56			

Serbelodon barbourensis Frick, 1933

Figures 406–410

From Christmas quarry, near Ainsworth, Nebraska. Lower Pliocene.

Serbelodon barbourensis Frick, 1933. "New Remains of Trilophodont-Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, pp. 592, 594, 595. Type.—Mandible with M_2, M_3, and tusks. F:A.M. 25730. Horizon and Locality.—From Christmas quarry, near Ainsworth, Nebraska. Lower Pliocene. Type Figure.—Frick, *op. cit.*, figures 14, 16, and 27 (reproduced herewith as Fig. 408).

Materials.—From Christmas quarry, besides the type mandible (F:A.M. 25730), were secured the following:

F:A.M. 25728 "Adolescent mandible with m_1-m_2, m_3 germ and incisors. Figured this paper, *Fig. 14.*"

F:A.M. 25729 "Partial cranium with m^2-m^3 and right tusk with enamel band. Figured this paper, *Fig. 27.* Tusk deeply worn, teeth much worn." (Fig. 408B of the present Memoir.)

F:A.M. 25735 "Inferior area of skull with m^2-m^3 and tusk alveoli. m^3 = (176) mm. Figured this paper, *Figs. 12C and 27.*" (Fig. 408C of the present Memoir.)

Also a considerable number of immature specimens fully listed by the author (1933, p. 595).

Specific Characters.—To the characters indicated in the above measurements, descriptions, and figures, should be added: (1) Superior molars relatively shorter and broader than in other genera or species of Serridentinæ, namely, M^3 (F:A.M. 25729) 141 mm. × 88 mm., index 63; type M_3 (F:A.M. 25730) 170 mm. × 77 mm., index 45; (2) apparently no serrations on the entotrefoils of the superior molars or ectotrefoils of the inferior molars; (3) ridge formula: M $3\frac{4}{4}$, M $2\frac{3}{3}$; (4) superior tusk extremely heavy, downwardly and outwardly curved, cross-section narrow, enamel band apparently broad and external in position.

Habits (Osborn).—The relatively medium size, the short and broad symphysis, the flattened incisors, the posterior grinders with four ridge-crests (Fig. 408 C1), as compared with *Trobelodon taoensis* (D, D1) with three ridge-crests and very simple foldings, distinguish *Serbelodon barbourensis* from all other phyla or genera known hitherto.

The occurrence of three entirely distinct kinds of Serridentines in the rich Ainsworth region is most surprising. This region also yields the 'prod-tusker' *Trilophodon osborni* and the tuskless (?) *T. phippsi* in association with *Hipparion sanfondensis* and representatives of the following genera and species: *Ocalientinus ojocaliensis*, *Trilophodon* (*Tatabelodon*) *gregorii*, and *Trobelodon taoensis*.

Serbelodon burnhami Osborn, 1933

Figures 406, 409, 410

From near Ricardo, San Bernardino County, California. Upper Pliocene.

Through the courtesy of Mr. Childs Frick, the present author was afforded the opportunity in 1933 of describing a new and unusual shovel-tusker from California, which he named *Serbelodon burnhami* after Mr. Frederick Burnham, brother-in-law of Mr. Blick to whom American palæontology is so greatly indebted for his very successful explorations in the Pliocene fauna of North America. "Fragments to date [April 12, 1933] evidence an associated fauna that includes a moderate sized horse (*?Pliohippus*), a large and a small sized camel, and an antelope (*?Merycodus*)."

The most distinguishing characteristic of this Serbelodont shovel-tusker is the *absence of dentinal rod-cones*, which, so far as known, are absent in Amebelodonts and present in Platybelodonts; the specimen accordingly was assigned to *Serbelodon*, a genus of the subfamily Serridentinæ.

Serbelodon burnhami Osborn, 1933. "*Serbelodon burnhami*, a New Shovel-tusker from California," Amer. Mus. Novitates, No. 639, June 29, 1933, pp. 1–5 (Osborn, 1933.909). Type.—Anterior portion of mandible with two incisive teeth, in the Frick Collection of the American Museum (F:A.M. 18228). Horizon and Locality.—Discovered by Mr. John C. Blick in February, 1933, "just above the last basalt flow some miles northeast of Ricardo post office [San Bernardino County, California] and apparently in or near the base of the Ricardo." Upper Pliocene. Type Figure.—*Op. cit.*, 1933.909, figs. 1 and 2. Referred Specimens.—"Two superior tusk fragments [were] received with the symphysis—a much aged and worn distal fragment, F:A.M. 18228A, and a distal section of a smaller tusk, F:A.M. 18228B." A few limb bones, right radius and ulna, left ulna and semilunar (F:A.M. 18228) were directly associated with the type mandible.

Type Description.—(Cf. Osborn, 1933.909) The type consists of the anterior portion of the mandible with two broad, flattened incisive teeth and, as compared with *Platybelodon grangeri*, relatively narrow rostrum. It is also apparently distinguished by the absence of the dentinal rod-cones characteristic of *Platybelodon grangeri*. The shape of the rostrum suggests comparison with that of *Serbelodon barbourensis* (F:A.M. 25730). The size of *S. barbourensis* of the Lower Pliocene of Ainsworth, Nebraska, is similar to that of *Serridentinus serridens* of the Lower Pliocene of Texas, and the size of *Serbelodon burnhami* of the Upper Pliocene of California will probably be found to equal that of *Platybelodon grangeri* of the Upper Miocene of Mongolia. Not only in size but in the evolution of the shovel tusks, *S. burnhami* is far more primitive than *S. barbourensis*.

Comparative Measurements

	Serbelodon barbourensis F:A.M. 25730	*Serbelodon burnhami* F:A.M. 18228	*Platybelodon grangeri* Amer. Mus. 26468
Condyle to extremity of symphysis	910 mm.		1300 mm.
Length of incisors	380	610	510
Terminal width of incisors	77	133	163
Combined width of incisors at emergence from ramus	177	313	342
Maximum thickness of tusk	45	47	32
Length of symphysis	305	630e	640
Width of ramus across narrowest part	178	296	151

The incisors of the *Serbelodon burnhami* type resemble those of the *S. barbourensis* type in evidence of superior wearing abrasion by the proboscis and of lateral and inferior rounding action, leaving them gently rounded or convex as viewed from in front, whereas in *Platybelodon grangeri* there is less evidence of superior abrasion by the proboscis than of strong evidence of the sharp chisel-shaped edge being produced by wear on flattened stones, this being characteristic of all the incisive teeth in the large American Museum collection from the Tung Gur beds of the Gobi Desert representing all stages of growth. Secondly, in *Serbelodon* the upper face of the incisors is transversely concave and upcurved on the outer border while that of *Platybelodon* is relatively plain. Thirdly, there is no trace of dentinal rod-cones in *Serbelodon*, the interior of the tusks being pure dentine.

The symphysis of *Serbelodon burnhami*, while badly fractured, broadly resembles that of *S. barbourensis* in lacking the pronounced broadening of the rostrum characteristic of *Platybelodon grangeri*, the sides converging gradually into the sharp superior border and relatively stout section of the ramus even at its narrowest point in contrast to the extremely compressed ramus of *Platybelodon*. While the *S. burnhami* jaw is nearly double the size of that of *S. barbourensis*, it nevertheless exhibits numerous similar generic characters although very clearly separated as to species.

The fortunate discovery of this specimen has made possible the expansion of the generic definition of *Serbelodon*, as given on page 443 of the present Memoir.

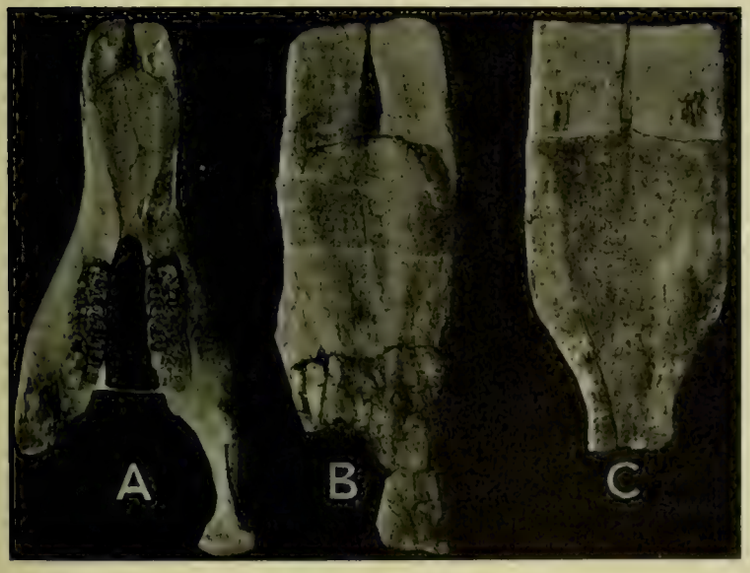
The superposed outlines (Fig. 410) of the shovel-tusks and flat-tusks emerging from the rostrum display the marked differences between the broad and relatively short tusks of *Platybelodon grangeri* and *Torynobelodon barnumbrowni* and the elongate and relatively narrow incisive tusks of *Amebelodon fricki* and *T. loomisi* which closely resemble each other, whereas *P. grangeri* with its chisel-edged incisors differs from *T. barnumbrowni* with its irregular anterior incisive border.

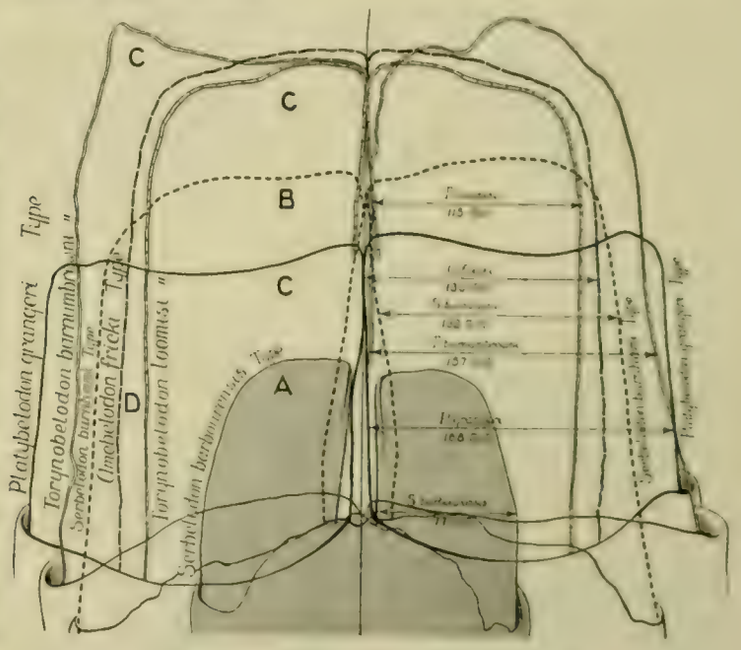
Osborn, 1933: The analogies or similarity of function between *Serbelodon* with solid ivory tusks, *Ambelodon* with extremely elongate tusks and dentinal laminæ, and *Platybelodon* with extremely broad and short tusks and dentinal rod-cones (Figs. 430, 431), are clearly displayed in figures 409 and 410. While the incisive teeth of *Serbelodon* are superficially similar to those of *Amebelodon* and *Platybelodon*, they are sharply distinguished by the solid ivory without a trace of dentinal rod-cones. The grinding teeth of *Serbelodon* are of very primitive serridentine pattern, broadly similar to those of *Platybelodon* with their extremely progressive serridentine pattern; on the other hand, both are in wide contrast to the grinding teeth of *Amebelodon* which are very similar to those of *Trilophodon*. We observe, therefore, a triple shovel-tusk analogy between the widely distinguished generic types; together they constitute a proof of widespread and extraordinarily favorable structure for digging up roots and bulbs along the borders of lakes and ponds containing rich and succulent tubers.

Serbelodon(?) **præcursor** Cope, 1892, 1893

Mt. Blanco, Llano Estacado, Texas. Upper Pliocene, Blanco formation.

The species '*Dibelodon*' *præcursor* Cope, was first considered by the present author as referable to the genus *Serridentinus*, consequently the description and figures will be found on pages 431, 432 above, this chapter. It proves on further study, however, to belong rather to Frick's genus *Serbelodon*, although the generic reference is still doubtful.





ANALOGOUS SHOVEL-TUSK ADAPTATIONS OF SERBELODON (A, B), PLATYBELODON AND TORYNOBELODON (C), AND AMEBELODON (D)

A, B, *Serbelodon*, primitive and progressive species, no dentinal rod-cones, subfamily SERRIDENTINÆ.
C, *Platybelodon* and *Torynobelodon*, progressive species, dentinal rod-cones, subfamily PLATYBELODONTINÆ.
D, *Amebelodon fricki*, progressive species, dentinal laminæ, subfamily AMEBELODONTINÆ.

Fig. 409. *Serbelodon* and *Platybelodon* tusks compared.

A, Type mandible of *Serbelodon barbourensis* (F:A.M. 25730). Near Ainsworth, Nebraska.

B, Type mandibular rostrum of *Serbelodon burnhami* (F:A.M. 18228). Near Ricardo, California.

C, Referred mandibular rostrum of *Platybelodon grangeri* (Amer. Mus. 26468). Tung Gur horizon, Gobi Desert.

All to the same scale of about one-thirteenth natural size.

Fig. 410. *Serbelodon*, *Platybelodon*, *Torynobelodon*, and *Amebelodon* tusks, superposed.

C, *Platybelodon grangeri* type (Amer. Mus. 26200). Tung Gur horizon, Gobi Desert. Typical flat-tuskers with dentinal rod-cones.

C, *Torynobelodon barnumbrowni* type (Neb. Mus. 1-10-7-31) of Nebraska. With dentinal rod-cones.

C, *Torynobelodon loomisi* type (Neb. Mus. 2-3-9-28); near Republican City, Harlan County, Nebraska. With dentinal rod-cones.

D, *Amebelodon fricki* type (Neb. Mus. 4-4-27), Freedom, Frontier County, Nebraska. Typical shovel-tuskers with dentinal laminæ.

B, *Serbelodon burnhami* type (F:A.M. 18228), near Ricardo, San Bernardino County, California. With dentinal laminæ

A, *Serbelodon barbourensis* type (F:A.M. 25730), near Ainsworth, Nebraska. With dentinal laminæ

Genus: **TROBELODON** Frick, 1933

Genotypic species: *Trobelodon taoensis* Frick, 1933, from the Santa Fé marls, Santa Cruz, New Mexico.
Original reference: Bull. Amer. Mus. Nat. Hist., 1933, Vol. LIX, Art. IX, pp. 505 and 580.

Generic Characters.—Third superior molars extremely short, single trefoils, blunt cones; cranium broad; inferior tusks moderately heavy, biconvex, pointed, 'sub-shovel-tusker'; mandible relatively decurved.

Trobelodon taoensis Frick, 1933

Figures 281F, 406, 408, 411

From Santa Cruz, New Mexico. Santa Fé marls (rare), Mio-Pliocene, also of Ainsworth, Nebraska.

This animal is of doubtful phylogenetic relationship; it is certainly not a Longirostrine, nor a Rhynchorostrine. While its molar trefoil structure is of *primitive Serridentine* type, its third superior molars are extremely short with only three ridge-crests.

(Frick, letter, Sept. 26, 1933): *Trobelodon*—Tro [glo] *belodon* —cave "belodon" in reference to crushed occurrence. The initial "T" of the last two subgenera [*Tatabelodon* and *Trobelodon*] recalling the "T" of *Trilophodon* with which the two were grouped in the "Longirostrines" proper [see Frick, 1933, p. 576].

Trobelodon taoensis Frick, 1933. "New Remains of Trilo-

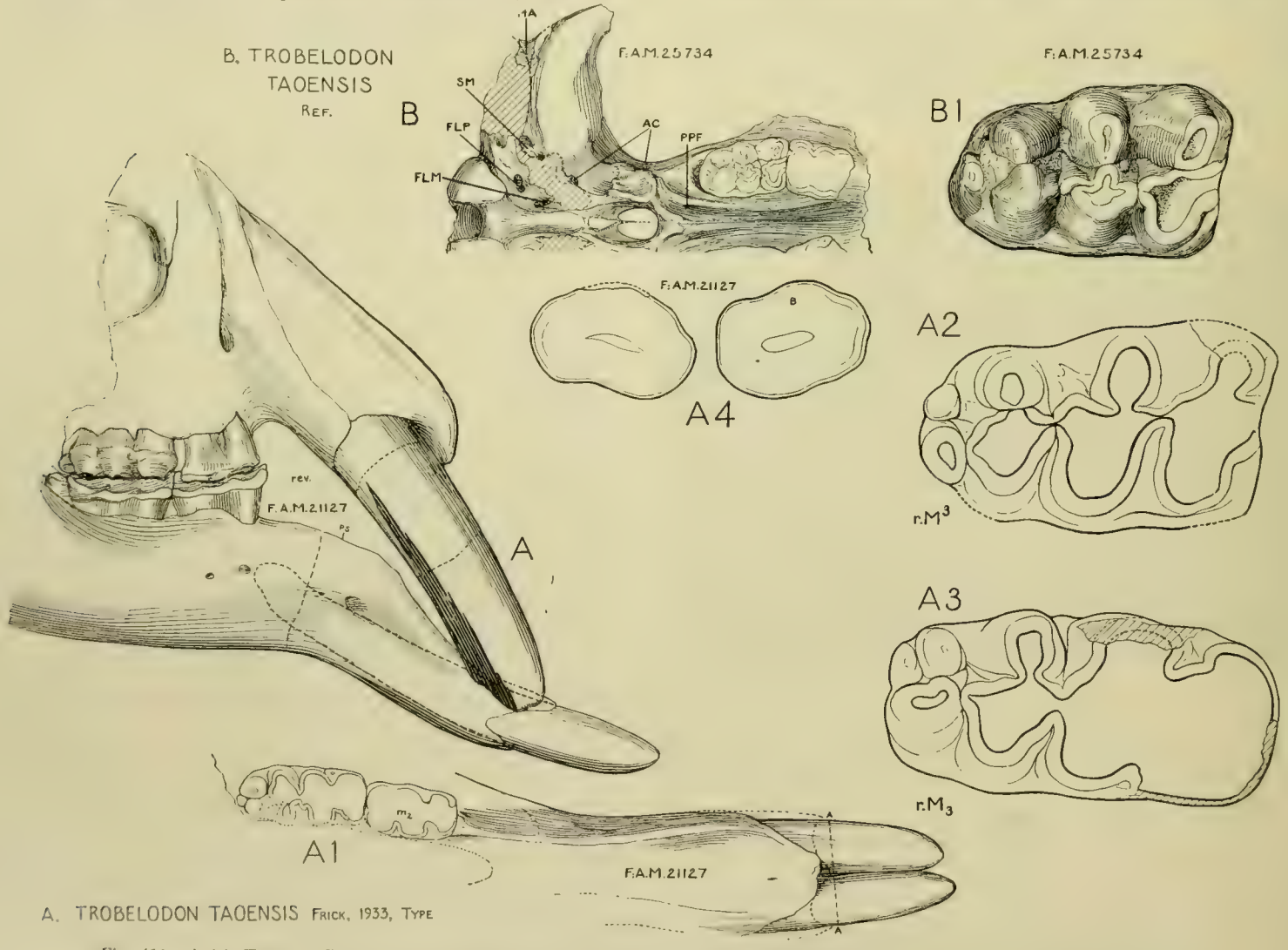


Fig. 411. A-A4, Type of Short-jawed Trobelodon taoensis Frick, 1933, Frick Collection, Santa Cruz, New Mexico, and B, B1, Referred Cranium from Ainsworth, Nebraska

After Frick, 1933, Figs. 2, 12C, 13, 18, 27. See also figure 281F of present Memoir. Genotype cranium and mandible one-tenth natural size; molars about one-third natural size; referred cranium about one-eighth natural size.

A, *Genotype* cranium and mandible, length 1300e mm. (F:A.M. 21127), after Frick, 1933, fig. 2. A1, Same, mandible in superior view. A2, Same, third right superior molar, r.M^3, trilophoid, ap. 176 mm., tr. 95 mm., index 54. A3, Same, third inferior molar, r.M$_3$, 4 ridge-crests, ap. 185e mm., tr. 81 mm., index 45e. A4, Transection of inferior molars.

B, *Referred* cranium (F:A.M. 25734) from Ainsworth, Nebraska, posterior moiety, right side only in drawing. B1, Same, third right superior molar, r.M^3, ap. 123 mm., tr. 80 mm., index 65.

phodont-Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, pp. 505, 509, 534, 547, 548, 571, 572, 573, 576, 580, 583, 584, 585. TYPE.—(*Op. cit.*, p. 580): "Crushed maxilla and mandible with $m\frac{2}{2}$-$m\frac{3}{3}$, superior tusks and inferior incisors. m_3=((185))[1] mm. F:A.M. 21127. Figured this paper, *Figs. 2, 13, 18.*" HORIZON AND LOCALITY.—Discovered in 1930 at Santa Cruz, New Mexico. Santa Fé marls, Mio-Pliocene. TYPE FIGURE.—*Op. cit.*, figs. 2, 13, and 18.

SPECIFIC CHARACTERS.—(Frick, 1933, p. 576): "Elongate symphysis with heavy flattened to spatulate tending incisors, roots extending well posterior to p.s. and adjoining m_2. Superior tusks reduced by wear to large stubs, enamel band moderate and proximally attenuated." Incisors heavy to buttress-like (cf. p. 547). M^3, ap. 176 mm., M_3, 185e mm. (worn). "The type specimen is particularly interesting on account of the heaviness of the inferior incisors, the cross-section of these being exceeded only in the New Mexican collection by the Battleship Mountain specimen, F:A.M. 21140 [*Tatabelodon riograndensis*]" (p. 581).

MATERIALS.—Besides the type maxilla and mandible (Fig. 411), Frick designates F:A.M. 21130 as "*Trobelodon taoensis*, Variant A," a much crushed ramus and symphysis with M_2-M_3 and tusks from Ojo Caliente, New Mexico, described on page 581 and figured (tusk sections) on page 550; he suggests that this ramus may represent the female of the genotype (F:A.M. 21127). The anteroposterior measurement of M_3=166e mm. Most important is F:A.M. 25734, posterior half of cranium, with both M^2 and M^3, from the vicinity of Ainsworth, Nebraska, determined by the present author as belonging to *Trobelodon taoensis* (erroneously referred by Frick, p. 595, to *Serbelodon barbourensis*).

Distinctive Characters, Osborn, 1933: (1) Third *superior* molars three ridge-crested, relatively short and broad, breadth-length index 54–65. (2) Third *inferior* molars four ridge-crested, relatively short and broad, breadth-length index 45–47. (3) Expanded entotrefoils in superior molars as in *Serridentinus*, in contrast to *Rhynchotherium* with expanded mesotrefoils in relatively short third superior molars, e.g. *Rhynchotherium brevidens;* expanded *ectotrefoils* in four crested third inferior molars. (4) Inferior incisors of the transversely ovate 'prod-tusker' type, as in *Serridentinus*. (5) Relatively broad or brachycephalic cranium, rostrum, and inferior mandible. (6) Symphysis relatively long and narrow, slightly upcurved as in *Aybelodon*. (7) These several characters appear to separate *Trobelodon* from either of the Mio-Pliocene types already known, especially the three crested third superior molars.

The supposed male genotype of *Trobelodon* (F:A.M. 21127) is an animal of large and robust size, M^3, 176×95 mm., M_3, 185e × 84 mm., in contrast to the *supposed female* from Ainsworth (F:A.M. 25734), M^3, 123×80 mm. This much smaller female skull (F:A.M. 25734) is apparently brachycephalic, width transversely across zygomata 580 mm., occipital condyle to front of M^3 560 mm.

	Trobelodon taoensis			Length of Mandible	M^3 ap.	tr.	I.	M_3 ap.	tr.	I.
1930	F:A.M. 21127 type	Santa Cruz, N.M.	Maxilla and mandible	1300e	176×95		54	185e×84		45e
1931	F:A.M. 21130	Ojo Caliente, N.M.	Mandibular ramus and symphysis					166e×78		47e
1932	F:A.M. 25734	Near Ainsworth, Neb.	Cranium		123×80		65			

INCERTAE SEDIS

Serridentinus barstonis Frick, 1933

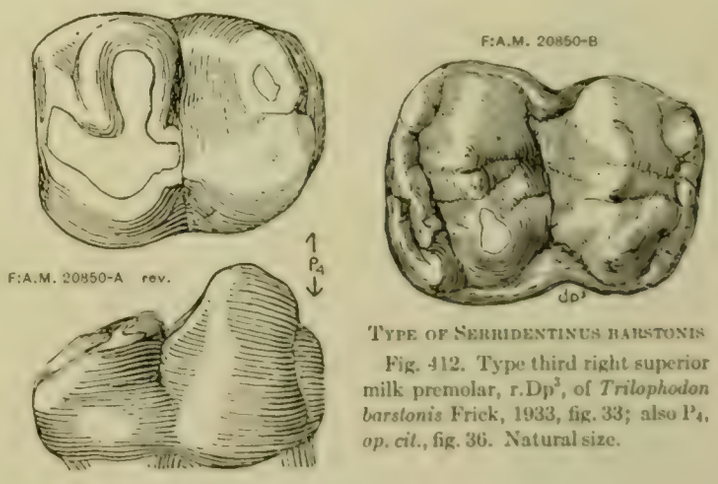
Figure 412

From the Barstow Mio-Pliocene, Mohave Desert, California.

(?) *Trilophodon barstonis* Frick, 1933. "New Remains of Trilophodont-Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, pp. 506, 520, 534, 607, 650. TYPE.—(*Op. cit.*, p. 607): . . . "dp^3, right, in maxillary fragment. (Size large.) F:A.M. 20850B. Figured this paper, *Fig. 33.* P_4, left, worn. Size of smallest Santa Fé p_4. F:A.M. 20850A. Figured this paper, *Fig. 36.*" HORIZON AND LOCALITY.—Mohave Desert, California, Barstow Mio-Pliocene. TYPE FIGURE.—*Op. cit.*, figs. 33, 36.

TYPE DESCRIPTION.—"Mastodont remains are extremely scarce in the Barstow deposits, and so far known only in a dp^3, p_4, a femur, etc. fragments from the Uppermost horizon. The specimens seem typical of the Longirostrines." Measurement (anteroposterior) of dp^3, unworn, 45 mm.; of p_4, worn, 41 mm.

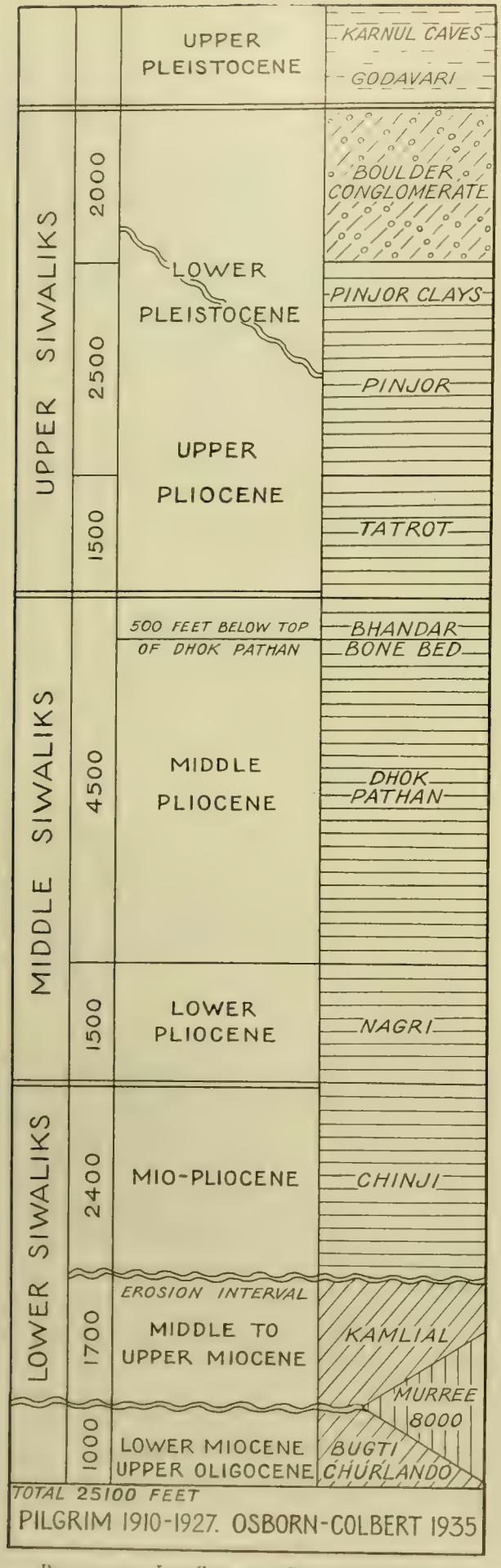
MATERIALS.—Besides the type Dp^3 (F:A.M. 20850B), and P_4 (F:A.M. 20850A), Frick has referred (p. 607) to this species a femur (F:A.M. 20850C) measuring 1111 mm., three (?) carpals and one phalanx (F:A.M. 20850C). He does not figure these in his paper. He remarks on page 613 that "slightly the largest element in the collection is a lone femur from Barstow, California. The length . . . exceeds that of the femur of the Warren mastodon, approximates that of a specimen of the Alaskan mammoth, and is nearly twice the length of the smallest femur from the Santa Fé marls."



TYPE OF SERRIDENTINUS BARSTONIS

Fig. 412. Type third right superior milk premolar, r.Dp^3, of *Trilophodon barstonis* Frick, 1933, fig. 33; also P_4, *op. cit.*, fig. 36. Natural size.

[1](( ))=estimated.



KARNUL CAVES: No proboscideans. *Equus onager, Cynocephalus.*

JUMNA, GODÁVARI, NERBUDDA: *Palæoloxodon namadicus* type, *Stegodon ganesa* ref., *S. insignis* ref., *?Elephas (Hypselephas) hysudricus* ref.

Summit of Barnum Brown's Collections

[PROVISIONAL SEQUENCE OF PLIO-PLEISTOCENE SPECIES]

BOULDER CONGLOMERATE: *Elephas (Hypselephas) hysudricus* type and ref., *Platelephas platycephalus* type, *Stegodon ganesa* type and ref., *S. insignis* type and ref.

AND *Dicerorhinus platyrhinus, Equus sivalensis* type, *Camelus sivalensis.*

PINJOR: *Archidiskodon planifrons* type and ref., *Stegodon pinjorensis* type, *Pentalophodon sivalensis* type(?), *Stegolophodon stegodontoides* type(?).

[The upper levels of the Pinjor are regarded as Lower Pleistocene; the lower levels as Upper Pliocene. Fossils are very rare in the Boulder Conglomerate. Pinjor fossils occur on eroded surfaces, which renders it difficult to determine their exact geologic level. The most numerous proboscidean specimens are upper and lower grinding teeth of *Archidiskodon planifrons,* believed by Osborn to be a true Upper Pliocene stage; Brown collected only one important specimen (*Stegodon pinjorensis*) *in situ* in the Pinjor.]

TATROT: *Pentalophodon falconeri* type.

DHOK PATHAN: *Anancus perimensis* ref., *Deinotherium indicum* ref., *Serridentinus browni* ref., *S. hasnotensis* cotypes and ref., *S. metachinjiensis* ref. (100 ft. above Bhandar bone bed), *Synconolophus corrugatus* type, *S. dhokpathanensis* type, paratypes, and ref., *S. hasnoti* ref., *S. propathanensis* type, *S. ptychodus* ref. (1000 ft. below Bhandar bone bed), *Stegodon bombifrons* type, *S. elephantoides* (=*cliftii*) ref., *Stegolophodon cautleyi* ref., *S. latidens* ref., *Tetralophodon (Lydekkeria) falconeri* type and ref., *T. punjabiensis* type, *Trilophodon hasnotensis* type (1000 ft. below Bhandar bone bed).

JAMMU AND KANGRA: *Deinotherium indicum* ref., *Stegolophodon latidens* ref., *Synconolophus hasnoti* type, *Tetralophodon punjabiensis* ref. =DHOK PATHAN AGE.

PERIM ISLAND: *Anancus perimensis* type, paratype, and ref., *Deinotherium indicum* type, *D. perimense* = *D. indicum, D. angustidens* type, *Stegolophodon cautleyi* type and ref., *S. latidens* ref. =DHOK PATHAN AGE.

UPPER CHINJI: *Deinotherium indicum* ref., *Trilophodon macrognathus* type.

LOWER CHINJI: *Anancus perimensis* ref. (800 ft.), *A. properimensis* type (800 ft.), *Deinotherium indicum* ref., *D. pentapotamiæ* type, *D. sindiense* type (Sind), *Rhynchotherium chinjiense* type (600 ft.), *Serridentinus browni* type (800 ft.), *S. metachinjiensis* type (800 ft.), *S. chinjiensis* type (700 ft.), *S. prochinjiensis* type (600 ft.), *Stegolophodon nathotensis* type, *S. cautleyi progressus* type (2000 ft.), *Synconolophus ptychodus* type (800 ft.), *S. ptychodus* ref. (2000 ft.), *S. ptychodus* ref. (400 ft.), *Trilophodon chinjiensis* type, (?)*T. macrognathus* ref.

Base of Barnum Brown's Sections

KAMLIAL: *Tetralophodon falconeri* ref. (Lower Manchhar), *Trilophodon pandionis* type (Larkana dist., Sind), *T. palæindicus* type (Punjab).

BUGTI: *Deinotherium náricum* = *D. indicum* var. *gajense* type, *Trilophodon cooperi* type and paratypes.

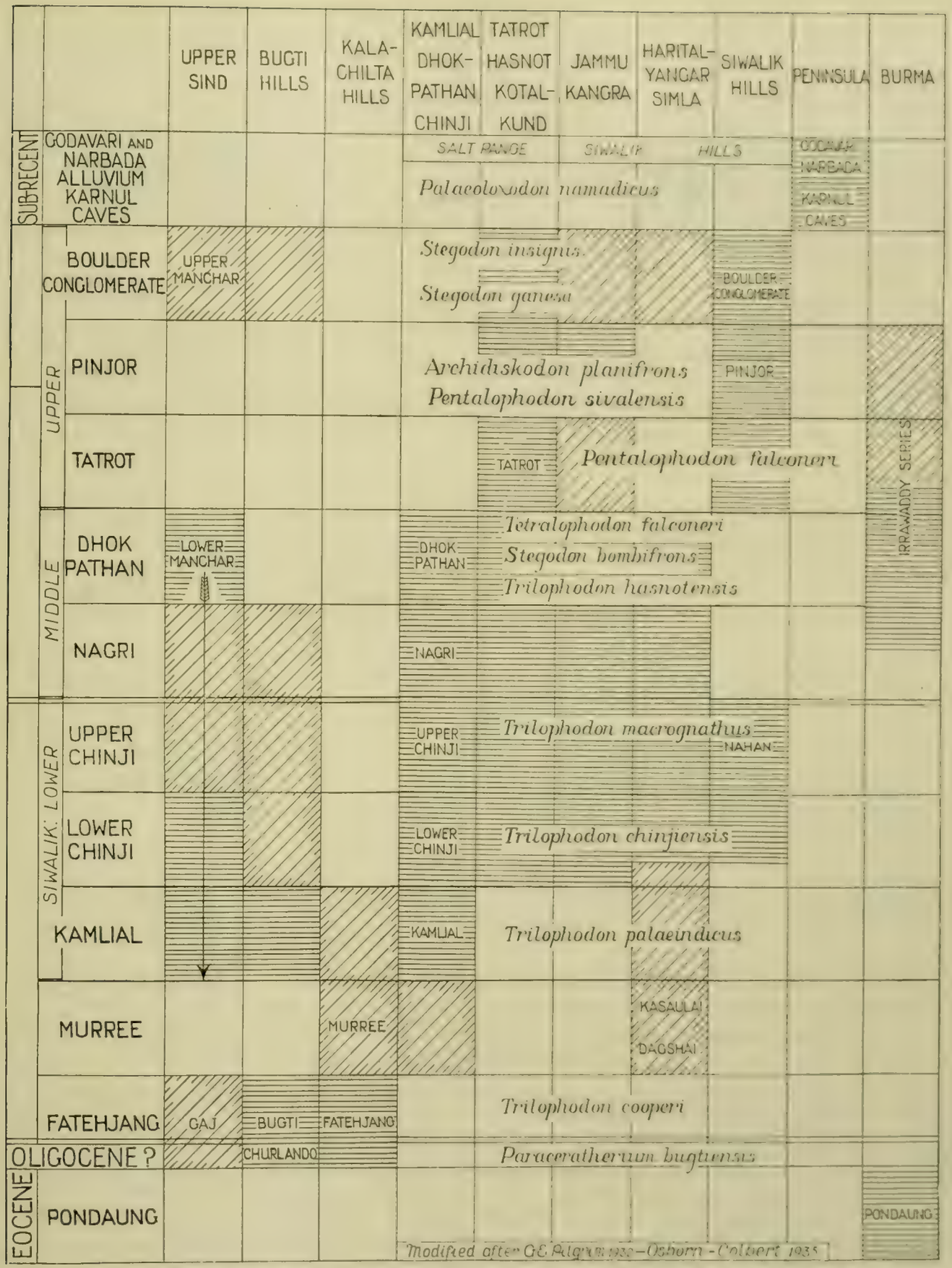
CHUR-LANDO: *Paraceratherium (Baluchitherium) bugtiense.* Absence of remains of *Deinotherium* and *Trilophodon* (Forster Cooper, 1935).

Compare (Fig. 414) more recent Horizon and Life Zone Chart of Pilgrim-Osborn-Colbert, also Table II, pp. 114 and 115, for Eurasiatic Mio-Pliocene Correlation (1932).

PROBOSCIDEAN LIFE ZONES AND GEOLOGIC HORIZONS OF INDIA, PILGRIM (1910–1927), PILGRIM-OSBORN (1927–1932), OSBORN-COLBERT (1935).

Fig. 413. Geologic levels of genera and species of Proboscidea as recorded by Falconer-Pilgrim (1845–1927), modified by precise geologic horizon levels recorded by Barnum Brown (1922, 1923), also by new generic and specific determinations by Osborn (1923–1935) for the present Memoir.

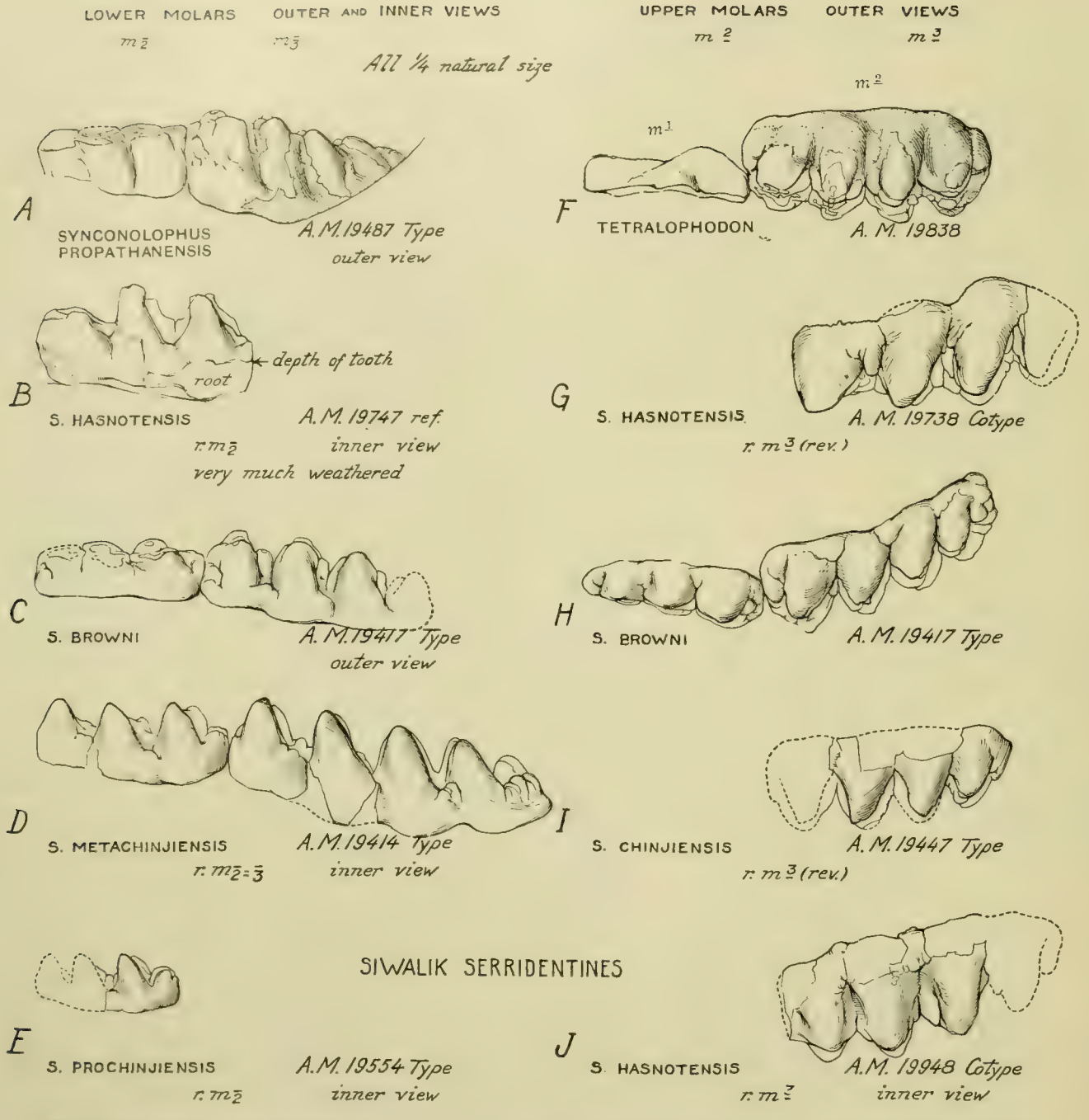
The erosion ≈≈ interval between "Boulder Conglomerate" and "Pinjor" renders the Plio-Pleistocene boundaries and levels very uncertain.



PROBOSCIDEAN LIFE ZONES (OSBORN, OCTOBER, 1935) WITHIN THE GEOLOGIC HORIZONS OF INDIA (PILGRIM, 1905–1932)

Fig. 414. Beginning in 1905 Pilgrim distinguished ten or more geologic horizons in India with faunistic correlations in Baluchistan and Burma, a most signal and important advance on the former classification into Lower, Middle, and Upper Siwaliks.

Pilgrim's own observations and fossil correlations up to the year 1932 tend to render these horizon levels more distinct. Cooper (1910, 1911) collected materials in the Bugti Hills which enable us to distinguish the Upper Oligocene and Lower Miocene levels. Still more precise leveling and collections of Barnum Brown (1922, 1923), analyzed by Brown and Colbert, and by Osborn especially in the preparation of the present Memoir, enable Osborn to designate nine mastodont and elephantoid life zones, as shown in the present diagram, and the entire generic and specific geologic levels (Fig. 413 opposite) so far as known at the present time.



Molar Evolution of the Serridentinæ (B–E, G–J) in India. Compare Synconolophus (A) and Tetralophodon sp. (F). Geologic Levels (Figs. 413, 414)

All figures one-fourth natural size

Fig. 415. Comparison of type, cotype, and referred inferior (B-E) and superior (G–J) molars of the Serridentinæ, also (A) l.M_{2-3} of *Synconolophus propathanensis* and (F) M^1, M^2 of *Tetralophodon* sp.

A, *Synconolophus propathanensis* type (Amer. Mus. 19487). External view of second and third left inferior molars, l.M_{2-3}.

B, *Serridentinus hasnotensis* ref. (Amer. Mus. 19747). Internal view of second right inferior molar, r.M_2, much weathered.

C, *Serridentinus browni* type (Amer. Mus. 19417). External view of second and third left inferior molars, l.M_{2-3}.

D, *Serridentinus metachinjiensis* type (Amer. Mus. 19414). Internal view of second and third right inferior molars, r.M_{2-3}.

E, *Serridentinus prochinjiensis* type (Amer. Mus. 19554). Internal view of second right inferior molar, r.M_2.

F, *Tetralophodon falconeri* (Amer. Mus. 19838). External view of first and second left superior molars, l.M , l.M^2. See pages 354 and 451.

G, *Serridentinus hasnotensis* cotype (Amer. Mus. 19738). External view of third right superior molar, r.M^3 (reversed).

H, *Serridentinus browni* type (Amer. Mus. 19417). External view of second and third right superior molars, r.M^{2-3}.

I, *Serridentinus chinjiensis* type (Amer. Mus. 19447). External view of third right superior molar, r.M^3 (reversed).

J, *Serridentinus hasnotensis* cotype (Amer. Mus. 19948). Internal view of third right superior molar, r.M^3.

Observe in the ascending series (left column, E–B) the marked increase in size, hypsodonty, and deposition of cement. Compare these outlines with those in figure 385: *Ocalientinus* (*Ser.*) *floridanus*, *O.* (*Ser.*) *republicanus*, *O.* (*Ser.*) *obliquidens* from America, *Serridentinus metachinjiensis* from India, and *S. mongoliensis* from Mongolia, also outlines in figure 350.

10. PRIMITIVE AND PROGRESSIVE SERRIDENTINÆ OF THE SIWALIKS OF INDIA

A surprising and most welcome discovery in the Barnum Brown collection of 1922 from the Siwaliks is a relatively rich *Serridentinus* fauna, beginning at the 600 foot level of the Lower Chinji with the comparatively primitive low-crowned *Serridentinus prochinjiensis* Osborn, 1929 (Amer. Mus. 19554), which is comparable to *S. subtapiroideus* of Eibiswald, Middle Miocene of Styria, Austria, and *S. proavus* of Colorado; succeeded at the 700 foot level by the *Serridentinus chinjiensis* Osborn, 1929 (Amer. Mus. 19447), which is comparable to *S. lydekkeri* of China; and at the 800 foot level by the two species *Serridentinus metachinjiensis* Osborn, 1929 (Amer. Mus. 19414), which is comparable to *S. serridens* of the Clarendon beds, Lower Pliocene of Texas, and *S. productus* of the Santa Fé marls, Upper Miocene of New Mexico, and by the massive *Serridentinus browni* Osborn, 1926 (Amer. Mus. 19417). Much more recent (Dhok Pathan horizon, upper Middle Siwaliks) is the *Serridentinus hasnotensis* Osborn, 1929 (Amer. Mus. 19948, 19738), which resembles *Ocalientinus* (*Ser.*) *floridanus* and *O.* (*Ser.*) *bifoliatus* of Florida.

Specific evolution in the Serridentinæ proceeded at the same rate in Asia and in North America, as set forth in the following synopsis.

SYNOPSIS OF THE SERRIDENTINE SPECIES IN DESCENDING GEOLOGIC ORDER (FIG. 415)

Dhok Pathan	Upper Middle Siwaliks, 2 m. N. E. of Hasnot	Amer. Mus. 19948. *Serridentinus hasnotensis* Osborn, 1929, cotype, r.M^3 with 4+ ridge-crests (4⅓), very massive, prominent internal trefoils, slight rudiments of double trefoils. Height of metaloph 75 mm. Three anterior crests, proto-, meta-, tritolophs = 146 mm. Compare *O.* (*S.*) *floridanus*. (Fig. 415 J).
	Middle Siwaliks, above middle beds, 1 m. N. E. of Hasnot	Amer. Mus. 19738. *Serridentinus hasnotensis* Osborn, 1929, cotype, r.M^3 with 4⅓ ridge-crests, prominent internal trefoils, rudimentary external trefoils (cf. Amer. Mus. 19948). Meas.: ap. 190e mm., tr. 94 mm., height of metaloph 69 mm., ap. of proto-, meta-, tritolophs = 143 mm. (Fig. 415 G).
	Hipparion quarry level, 500 feet below top of Middle Siwaliks, 4 m. west of Dhok Pathan	Amer. Mus. 19838.[1] *Tetralophodon falconeri* Osborn, 1929, cotype. L.M^1 (?) and l.M^2. L.M^1 with four ridge-crests; ap. 108 mm., tr. 74 mm. L.M^2 with 4⅓ ridge-crests; ap. 160 mm., tr. 93 mm. Internal trefoils, rudiments of external trefoils, cement, very massive. Height of tritoloph of l.M^2 80e mm. (Fig. 415 F).
	Upper Middle or lower Upper Siwaliks, near Hasnot	Amer. Mus. 19529. *Serridentinus hasnotensis* ref. Protoloph of l.M^2 fractured posteriorly, very large, tr. 120 mm. L.M^3 tetartoloph fragment.
	Upper Middle Siwaliks, 2 m. west of Hasnot	Amer. Mus. 19545. *Serridentinus hasnotensis* ref. Tetartoloph and ½ ridge-crest (pentaloph) of l.M^3.
	Upper Middle Siwaliks, 2 m. N. E. of Hasnot	Amer. Mus. 19747. *Serridentinus hasnotensis* ref. R.M_2, proto-, meta-, and tritolophids fractured in ramus (Fig. 415 B).
	Hipparion quarry level, 500 feet below top of Middle Siwaliks	Amer. Mus. 19479. *Serridentinus hasnotensis* ref. Proto-, meta-, and tritolophs of l.M^3. Very much worn, fractured posteriorly. Width of metaloph 95 mm.
	Upper Middle Siwaliks, 1 m. N. E. of Hasnot, 100 feet above Bhandar bone bed	Amer. Mus. 19687. *Serridentinus metachinjiensis* ref. R.M_2, protolophid fragment; r.M_3 fractured in ramus, preserving only the protolophid.

[1]Molars M^1, M^2 (Amer. Mus. 19838), erroneously described as cotypes of *Serridentinus hasnotensis*, are referable to *Tetralophodon falconeri* (see footnote, p. 354 above).

	Lower Middle Siwaliks, 2 m. S. of Hasnot	Amer. Mus. 19753. *Serridentinus browni* ref. Proto- and metalophs of l.M^3, tr. 85e mm., height of metaloph 57 mm.; l.M_2 proto- and metalophids, tr. 64 mm., height of metalophid 51 mm.
Lower Chinji	Lower Siwaliks, 800 feet above base, 1½ m. N. E. of Chinji Bungalow	Amer. Mus. 19417. *Serridentinus browni* Osborn, 1926, type. Right and left M^2, M^3, M_2, M_3. Meas.: r.M_2, ap. 118 mm., tr. (tritolophid) 71 mm.; r.M_3, ap. 170e mm., tr. 80 mm. (metalophid), height of tritolophid 45e mm.; r.M^2, ap. 118 mm., tr. 74 mm.; r.M^3, ap. 162 mm., tr. 80 mm., height of metaloph 45+ mm. Left superior tusk, I^2, and right and left inferior tusks, I_2 (Figs. 415 C and H, 416, 418).
	Lower Siwaliks, 800 feet above base, 1 m. N. W. of Chinji Bungalow	Amer. Mus. 19414. *Serridentinus metachinjiensis* Osborn, 1929, type. R.M_3 with 4½ ridge-crests, subhypsodont, no cement. Meas.: ap. 214 mm., tr. 85 mm., height of metalophid 75 mm. R.M_2, ap. 131 mm., tr. (protolophid) 61 mm., (tritolophid) 71 mm., i.e., widening posteriorly, height of metalophid 53 mm. (Figs. 415 D, 418 B). Compare *S. serridens* (Lower Pliocene) and *S. productus* (Upper Miocene).
	Lower Siwaliks, 700 feet above base, 1½ m. W. of Chinji Bungalow	Amer. Mus. 19447. *Serridentinus chinjiensis* Osborn, 1929, type. R.M^3, ap. 160e mm., tr. 91 mm., height of metaloph 52e mm. (Figs. 415 I, 419).
	Lower Siwaliks, 600 feet above base, 2 m. W. of Chinji Bungalow	Amer. Mus. 19554. *Serridentinus prochinjiensis* Osborn, 1929, type. Posterior half of crown, r.M_2. Meas.: ap. 105e mm., tr. 58 mm., height of tritolophid 41e mm. (Figs. 415 E, 420).

Serridentinus hasnotensis Osborn, 1929

Figure 415

Upper Middle Siwaliks, Middle Pliocene, near Hasnot, Dhok Pathan horizon, India.

Serridentinus hasnotensis Osborn, 1929. "New Eurasiatic and American Proboscideans," Amer. Mus. Novitates, No. 393, Dec. 24, p. 2.

Cotypes.—Two specimens collected by Dr. Barnum Brown in 1922, as follows: Amer. Mus. 19948, an incomplete third right superior molar, r.M^3, with 4+ ridge-crests (4⅓), and Amer. Mus. 19738, a third right superior molar, r.M^3, with 4⅓ ridge-crests (see Fig. 415 J and G). Cotype Figures.—*Op. cit.*, Osborn, 1929.797, p. 3, fig. 3.

Referred Specimens.—Amer. Mus. 19529, protoloph of a left superior molar, l.M^2, fractured posteriorly; Amer. Mus. 19545, tetartoloph and one-fifth (pentaloph) of a left third superior molar, l.M^3; Amer. Mus. 19479, proto-, meta-, and tritolophs of a left third superior molar, l.M^3, fractured posteriorly; Amer. Mus. 19747, proto-, meta-, and tritolophids of a right second inferior molar, r.M_2, fractured in ramus.

Specific Characters.—"Ridge formula: M 2 $\frac{1/2\text{-}3\text{-}1/3}{4+\text{talon}}$ M 3. Ridge-crests massive, separate, vertical; strong internal, rudimentary external trefoils; cement in valleys. Measurements: r.M^3, height of metaloph 75 mm., three anterior crests, proto-, meta-, and tritolophs = 146 mm.; r.M^3, ap. 190e mm., tr. 94 mm., height of metaloph 69 mm., ap. of proto-, meta-, tritolophs = 143 mm."

Osborn, 1933: This stage corresponds closely with the four to five crested *Ocalientinus* (*Ser.*) *floridanus* (Figs. 379, 380), with the still more progressive *O.* (*S.*) *bifoliatus* of Florida (Fig. 376), but most closely with *O. ojocaliensis* of the Santa Fé marls, New Mexico. It differs widely from the subhypsodont species *O.* (*S.*) *obliquidens* and *Serridentinus guatemalensis*.

Serridentinus browni Osborn, 1926

Figures 415, 416, 418

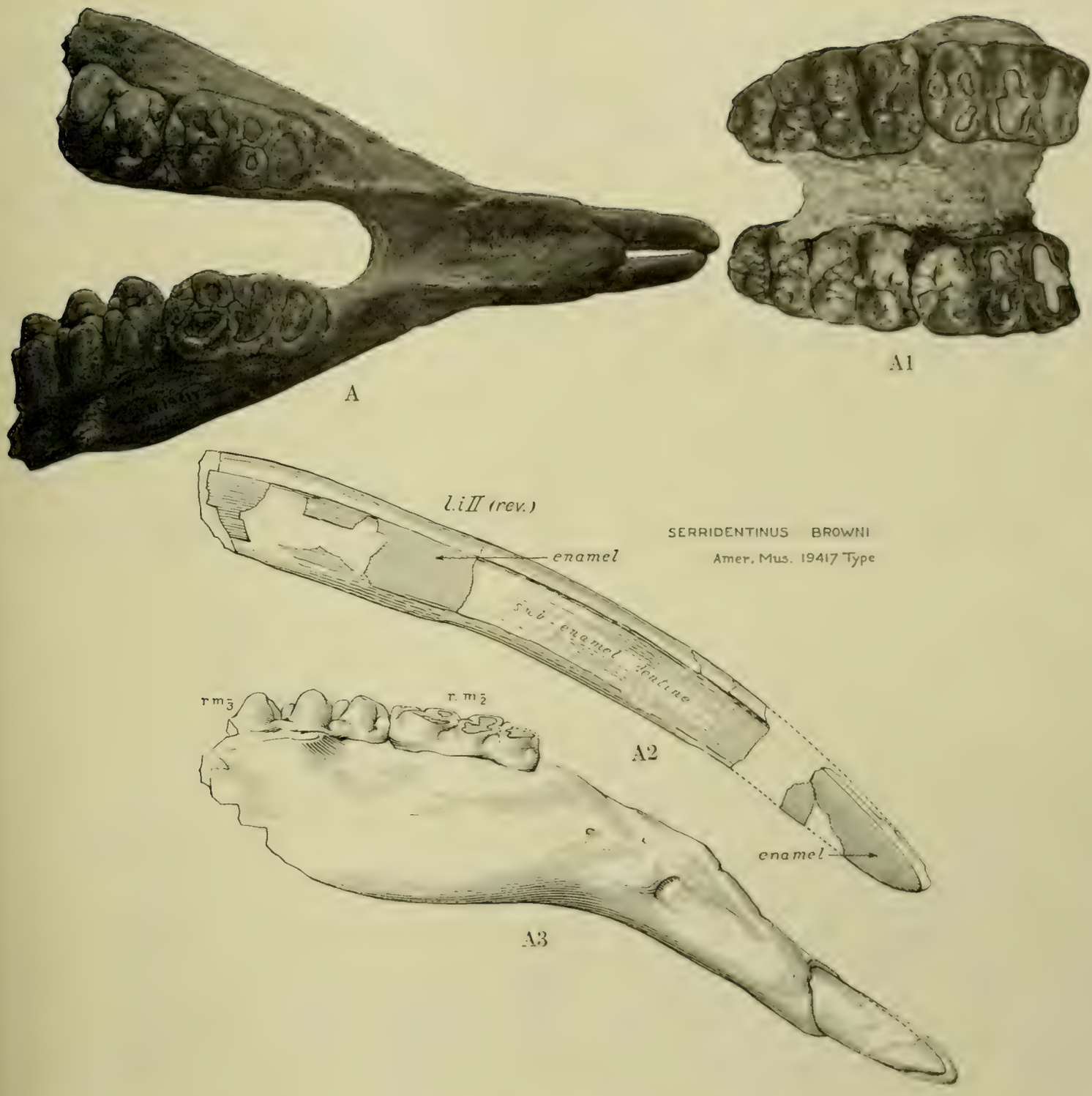
Mio-Pliocene, Lower Chinji horizon, 800 feet above base of Lower Siwaliks, a mile and a half northeast of Chinji Bungalow, India.

The discovery in the Mio-Pliocene of India of the type palate and jaws with grinding teeth and superior and inferior incisive tusks (Amer. Mus. 19417) of this south Asiatic species was one of the many notable achievements of Dr. Barnum Brown in his Siwalik explorations of the year 1922. As this was the first species in the Siwalik collection to be described by the present author, he took pleasure in naming it after the explorer, to whom the science of palæontology is so greatly indebted.

The type grinders, M^2-M_2, M^3-M_3, are found to be absolutely typical of *Serridentinus* and intermediate in size between the New Mexican species *S. productus* and the Floridian species *Ocalientinus* (*Ser.*) *floridanus*. As it belongs to a more blunt stage than either the Upper Miocene *S. productus* of New Mexico, or the Lower Pliocene *O.* (*S.*) *floridanus* of Florida, the trefoil spurs and conelets are more feebly developed; the tetartoloph is much more strongly developed than in *S. productus* but is much less progressive than in *O.* (*S.*) *floridanus;* the blunt, round-coned, rugose, strongly cingulate characters of the superior and inferior grinders are broadly similar to those of *O.* (*S.*) *floridanus;* it is lower crowned and much more primitive than *O.* (*S.*) *floridanus*.

Serridentinus browni Osborn, 1926. "Additional New Genera and Species of the Mastodontoid Proboscidea." Amer. Mus. Novitates, No. 238, Nov. 30, 1926, pp. 4–6, figs. 3, 4 (Osborn, 1926.706).

Type.—Posterior portion of maxilla containing the second and third superior molars of both sides, $M^{2\text{-}3}$, with unattached left superior tusk, also lower jaws with second and third molars of both sides, $M_{2\text{-}3}$, together with both tusks (Amer. Mus. 19417). Referred Specimen.—Amer. Mus. 19753. Two anterior ridge-crests (proto- and metalophs) of a left third superior



BLUNT-CONED TYPE OF SERRIDENTINUS BROWNI. LOWER CHINJI

Fig. 416. Type of *Serridentinus browni* Osborn, 1926 (Amer. Mus. 19417), from the Lower Chinji horizon, 800 feet above the base of the Lower Siwaliks, India. Brown Coll., 1922. Observe the bluntly rounded cones and conelets (cf. Figs. 418, and 415 H of the present Memoir). All figures one-fourth natural size.

(Upper) A, Mandible containing M_2 and anterior portion of M_3.

A1, Portion of type maxilla containing M^{2-3} of both sides. Compare *Serridentinus annectens* Mats., of Japan (Fig. 421).

(Lower) A2, Left superior tusk (rev.) showing broad enamel band.

A3, External aspect of mandible showing downturned rostrum and inferior 'uproot' or 'prod' tusks.

(A) and (A1) after retouched photographs; originally figured by Osborn (1926.706, figs. 3 and 4 respectively).

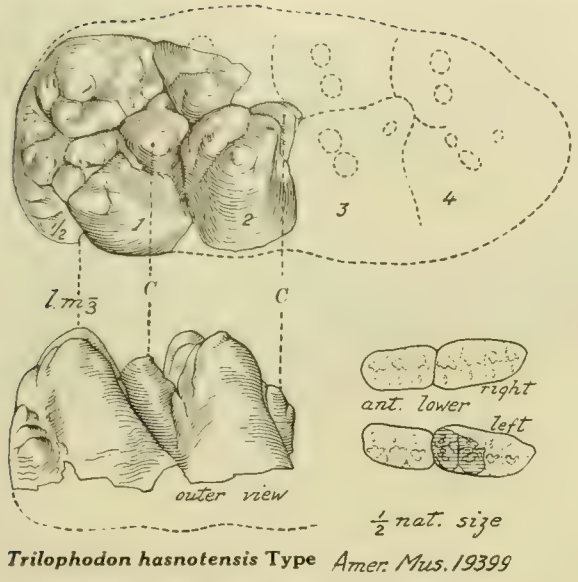


Fig. 417. *Trilophodon hasnotensis* sp. nov. (Amer. Mus. 19399). Anterior portion of a left inferior molar, l.M_3, showing metalophid, protolophid, and anterior half crest (½). One-half natural size. 4½ m. n. w. of Hasnot. Observe 'central conules' (C, C).

molar, l.M^3, tr. 85e mm., height of metaloph 57 mm.; two anterior ridge-crests of a left second inferior molar, l.M_2 (proto- and metalophids), tr. 64 mm., height of metalophid 51 mm. From the Dhok Pathan horizon, lower Middle Siwaliks, two miles south of Hasnot. Also Amer. Mus. 19443 (possibly referable to *Serridentinus browni*). A complete left third superior molar, l.M^3, with 4¾ ridge-crests, ap. 190 mm., tr. 90 mm., height of metaloph 63 mm., found one mile northwest of Chinji Bungalow, 1500 feet above the base of the Lower Siwaliks. Finally Amer. Mus. 19399, a third left lower molar fragment, proto- and metalophids only (Fig. 417), exhibiting strong central conules more progressive than *Trilophodon macrognathus* of the Upper Chinji (Fig. 222). Transferred in the present Memoir (p. 279) from *Serridentinus* to *Trilophodon hasnotensis* sp.nov.

Horizon and Locality.—Collected by Barnum Brown in 1922, from near Chinji Bungalow, Lower Chinji horizon, Lower Siwaliks, India, of Mio-Pliocene age. This horizon also yielded the type of *Deinotherium pentapotamiæ*, as well as *Deinotherium indicum* ref. and *Trilophodon chinjiensis* holotype Pilgrim-Osborn. The Lower Chinji horizon is of more recent geologic age than the Middle Miocene Sansan and Simorre of France containing the typical *Trilophodon angustidens*. See Table II. pp. 114, 115, also figures 413, 414, pp. 448, 449.

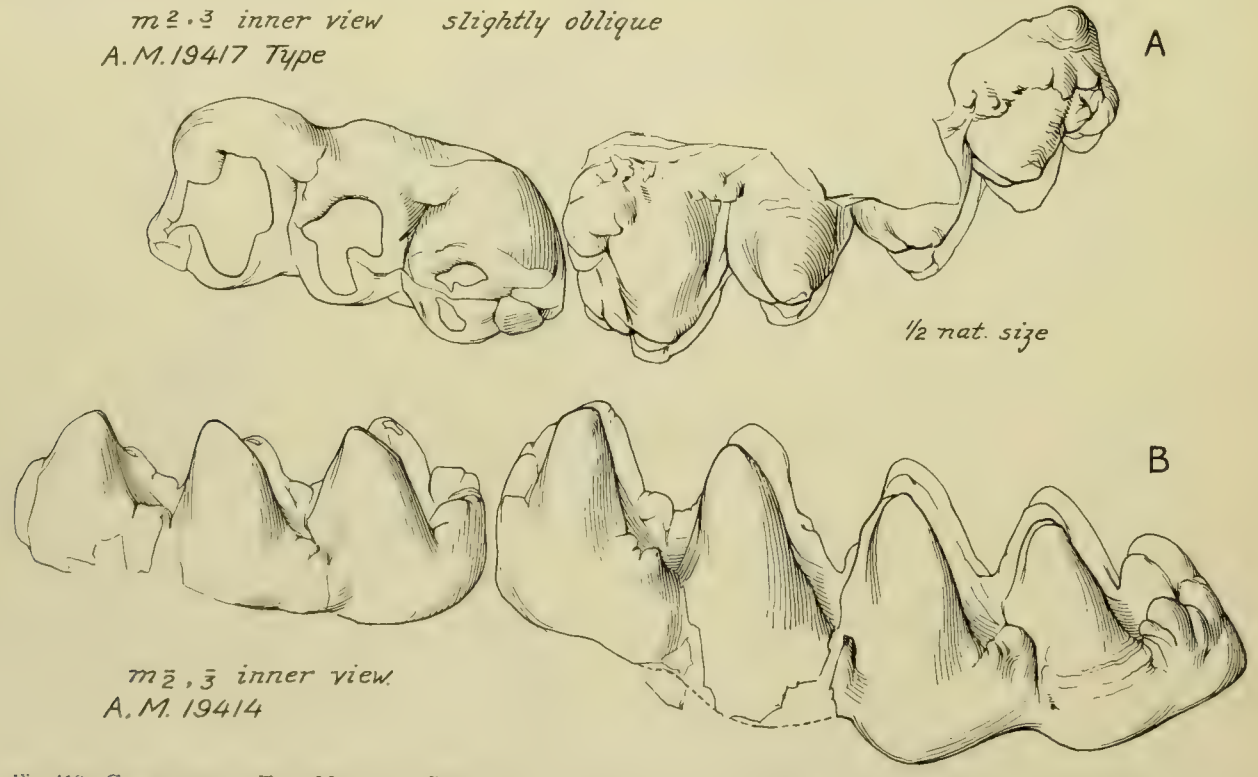


Fig. 418. Comparison of Type Molars of Serridentinus browni (A), Brachyodont, and S. metachinjiensis (B), Subhypsodont

Compare figure 415

A, Internal aspect of second and third right superior molars, r.M^{2-3}, of *Serridentinus browni* type (Amer. Mus. 19417). One-half natural size. Compare Osborn, 1926.706, p. 6, fig. 4.

B, Internal aspect of second and third right inferior molars, r.M_{2-3}, of *Serridentinus metachinjiensis* type (Amer. Mus. 19414). One-half natural size.

Observe the blunted cones of *Serridentinus browni* (A) in contrast to the elevated, pointed cones of *S. metachinjiensis* (B), the latter closely similar to *S. productus* of the Lower Miocene of Texas but of larger size.

Superior Molars. Type Characters (Amer. Mus. 19417).—Second superior molars (1) brachyodont, with (2) blunted, convex cones, (3) thick enamel, (4) obtuse internal trefoil spurs, and (5) characteristic tetartoloph rudiment bearing an internal ridge-crest with blunted conelets and terminating in a single blunt external cone (similar to *Serridentinus productus*). Third superior molars with (6) four blunt ridge-crests, proto-, meta-, trito-, and mm.; maximum diameter, parallel to enamel band, 82 mm.; width of enamel band 46 mm.; oval in section near distal end of tusk.

Pair of lower jaws with tusks, and second and third molars: Length of right and left tusks exposed 128 mm. and 145 mm. respectively; breadth of symphysis 92 mm., length of symphysis 231 mm.; length of right M^2 118 mm., breadth 74 mm., index

Comparative Measurements of Second and Third Superior and Inferior Molars

	Florida *Ocalientinus* (*Ser.*) *floridanus* Type M_3 (Nat. Mus. 3083). Casts of Metatypes; M^3 (Amer.Mus.17726); M_2 (Amer. Mus. 14384); M^2 (from Leidy and Lucas, 1896, Pl. II, fig. 6)			Siwaliks, India *Serridentinus browni* Type (Amer. Mus. 19417)			Texas *Serridentinus productus* Ref. (Amer. Mus. 10582)			Austria *Serridentinus subtapiroideus* Cotype (Cast Amer.Mus. 2572)		
Superior Molars	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.
M^2	125e	80e	64e	118	74	63	119	80	67	112	72	64
M^3	210	107	51	162	80	49	142	85	60	150	83	55
Inferior Molars												
M_2	127	80	63	118	71	60	124e	75	60e	(Est. from Schlesinger, 1917, Taf. VIII, fig. 1)		
M_3	226	85	38	170e	80	47e	163	76	47	172e	74e	43e

tetartolophs; (7) very rudimentary pentaloph cingulum (left side); (8) pentaloph rudiment (right side); (9) external cones surmounted by two or three conelets; (10) internal cones with anterior trefoil spurs bearing a single prominent conelet, with feeble or no posterior trefoil spurs, no posterior conelets.

Additional Characters and Measurements of the Type (Amer. Mus. 19417).—This material includes a left superior tusk, l.I^2, also a pair of lower tusks embedded in the jaws which contain the second and third molars of both sides; with bony septum between the small, rounded inferior tusks. The second molars, M_2, are worn and broken. The third molars are less worn and more complicated than in the type of *S. metachinjiensis* (Amer. Mus. 19414); they contain an accessory cusp, external to the main trefoil, between the protolophid and the metalophid, which is apparently absent or not accented in *S. metachinjiensis*. The measurements are as above.

Left tusk, I^2, somewhat crushed: Length as preserved 492 63; length of right M_3 170e mm., breadth 80 mm., index 47e; length of left M_2 115 mm., breadth 74 mm., index 64; left M_3 incomplete.

Comparison.—The above comparative measurements show that *Serridentinus subtapiroideus* of Austria, *S. productus* of Texas, *S. browni* of India, and *O.* (*S.*) *floridanus* of Florida increase progressively in size; also that while much less progressive than *O. floridanus*, *S. browni* is approximately of the same size. (2) The comparative ridge-crest formula in the same descending order is as below.

Osborn, 1929: In conclusion, *Serridentinus browni* belongs to the blunt-coned, massive, broad-crested series and is ancestral to the massive *S. hasnotensis* of the Dhok Pathan rather than to the subhypsodont, narrow-crowned *S. metachinjiensis*. The cranium is relatively broad and the rostrum of the jaw is narrow, abbreviated, and horizontal in comparison with the compressed, very broad, deeply channeled rostrum of *S. metachinjiensis*.

Ridge-crests	M^2	M^3	M_2	M_3
Ocalientinus (*Ser.*) *floridanus*, type	3¼	4⅓	3⅓	5¼
Serridentinus browni, type	3⅓	4⅓-⅓	3⅓	4¼
Serridentinus productus, ref.	3⅓	3⅓	3⅓	4⅓
Serridentinus subtapiroideus, cotypes	3	4		4⅓

Serridentinus metachinjiensis Osborn, 1929

Figures 385, 415, and 418

Lower Chinji horizon, 800 feet above base of Lower Siwaliks, one mile northwest of Chinji Bungalow, India. Mio-Pliocene. Brown Coll., 1922.

Serridentinus metachinjiensis Osborn, 1929. "New Eurasiatic and American Proboscideans," Amer. Mus. Novitates, No. 393, Dec. 24, 1929, p. 4.

Type.—Amer. Mus. 19414. Portion of right inferior ramus with M_2, M_3 complete, beautifully preserved (see Figs. 415 D and 418 B). Type Figure.—Osborn, *op. cit.*, 1929.797, p. 3, fig. 4.

Referred Specimen.—Amer. Mus. 19687. A right second inferior molar, r.M_2, protolophid fragment, and a right third inferior molar, r.M_3, fractured in ramus, preserving only the protolophid. From 100 feet above the Bhandar bone bed.

Specific Characters.—Right third inferior molar, r.M_3, with 4½ ridge-crests, subhypsodont, no cement, anteroposterior measurement 214 mm., transverse 85 mm., height of metalophid 75 mm.; r.M_2, anteroposterior measurement 131 mm., transverse (protolophid) 61 mm., (tritolophid) 71 mm., i.e., widening posteriorly, height of metalophid 53 mm. Single external trefoils, low postcingulum with many conelets and single prominent cone (tetartolophid); *S. serridens* exhibits two prominent cones, also *S. prochinjiensis* type has two cones, in fact, the double cones in M_2 are very characteristic. Summits of lophs with four to five conelets. Compare *S. serridens* of the Clarendon beds, Lower Pliocene of Texas, and *S. productus* of the Santa Fé marls, Upper Miocene of New Mexico.

Osborn, 1935: It is certainly gratifying and astonishing to find a third parallel in this close resemblance of *Serridentinus metachinjiensis* of India with *S. serridens* and *S. productus* of Texas and New Mexico. The four Indian and American parallels thus far observed are:

Serridentinus hasnotensis Osborn with *Ocalientinus* (*S.*) *floridanus* and *O.* (*S.*) *bifoliatus* of Florida, Lower Pliocene, and *O. ojocaliensis*, Mio-Pliocene of New Mexico.

Serridentinus metachinjiensis Osborn with *S. serridens* (Lower Pliocene of Texas) and *S. productus* (Upper Miocene of New Mexico). Compare figures 418 and 389.

Serridentinus chinjiensis Osborn with *S. lydekkeri* of China (Lower Pliocene?), and *S. serridens cimarronis* (Fig. 395) of the Lower Pliocene of Texas.

Serridentinus prochinjiensis Osborn with *S. proavus* (Fig. 362) of the Upper Miocene of Colorado.

Serridentinus chinjiensis Osborn, 1929

Figures 415 and 419

Lower Chinji horizon, 700 feet above base of Lower Siwaliks, one mile and a half west of Chinji Bungalow, India. Mio-Pliocene.

Serridentinus chinjiensis Osborn, 1929. "New Eurasiatic and American Proboscideans." Amer. Mus. Novitates, No. 393, Dec. 24, 1929, p. 5.

Type.—Amer. Mus. 19447. An imperfect right third superior molar, r.M^3, with 4 ridge-crests plus cingulum. Measurements: ap. 160e mm., tr. 91 mm., height of metaloph 52e mm. Type Figure.—Osborn, *op. cit.*, 1929.797, p. 4, fig. 5.

Specific Characters.—This stage is clearly distinguished from, and is much more primitive than *Serridentinus metachinjiensis* Osborn, i.e., more brachyodont, with smooth-sided crowns,

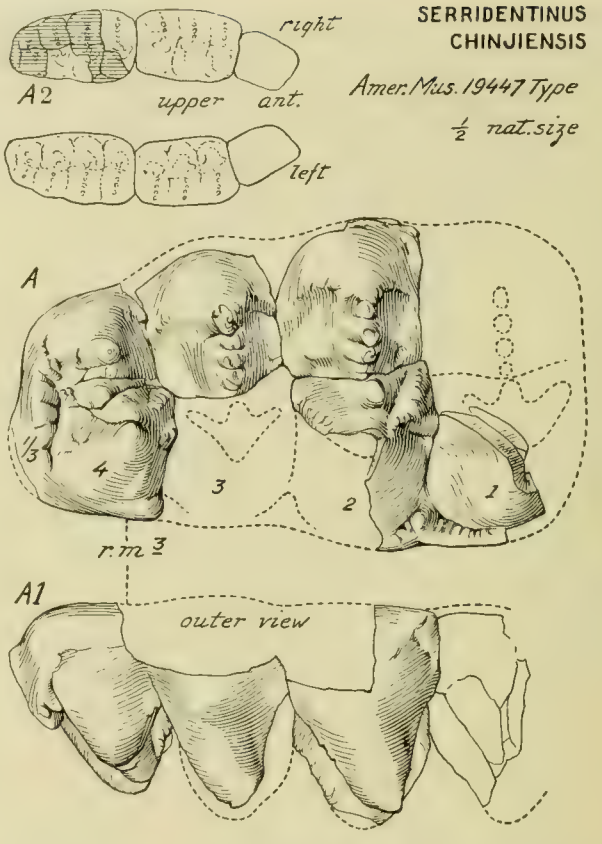


Fig. 419. Type of *Serridentinus chinjiensis* Osborn, 1929 (Amer. Mus. 19447), Lower Chinji horizon, 700 feet above base of Lower Siwaliks, India; a fractured third right superior molar, r.M^3. Compare figure 415 I. One-half natural size.

A, Crown view; A1, external view; A2, showing position in the molar series.

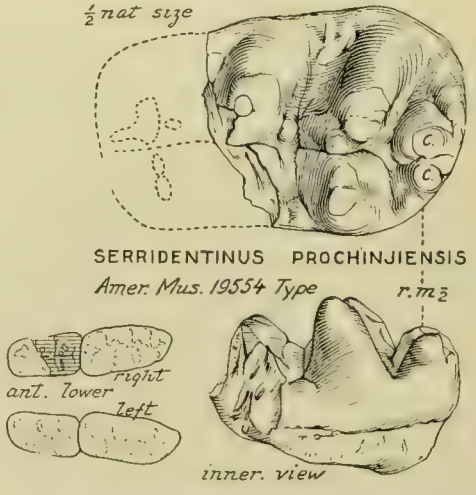


Fig. 420. Type of *Serridentinus prochinjiensis* Osborn (Amer. Mus. 19554), Lower Chinji horizon, 600 feet above base of Lower Siwaliks, India; a fractured second right inferior molar, r.M_2, lacking the protolphoid. One-half natural size.

7–6 conelets on metaloph and tritoloph, trefoils sharply defined in median aspect, both external and internal cones sloping inwards, contour of crowns subtriangular, broad anteriorly, narrowing posteriorly, tetartoloph with five to six conelets, internal cones less prominent than external. Close to *S. serridens* of Texas (Fig. 389).

Osborn, 1935: This single type specimen of the Lower Chinji horizon, 700 feet above the base of the Lower Siwaliks, resembles in its subtriangular crown the third superior molar of *Serridentinus serridens cimarronis* (Fig. 395) and *Serbelodon*(?) *præcursor* (Fig. 397) from Texas, with sharp trefoil ridges, and contrasts very widely with the massive, square-crowned *Serridentinus hasnotensis* and the oblong-crowned *S. browni*. Its delicate enamel lines and borders, with multiple conelets surmounting the lophs, distinguish it as a separate specific phylum.

Serridentinus prochinjiensis Osborn, 1929

Figures 415 and 420

Lower Chinji horizon, 600 feet above base of Lower Siwaliks, two miles west of Chinji Bungalow, India. Mio-Pliocene.

Serridentinus prochinjiensis Osborn, 1929. "New Eurasiatic and American Proboscideans." Amer. Mus. Novitates, No. 393, Dec. 24, 1929, p. 6.

Type.—Amer. Mus. 19554. A second right inferior molar, r.M_2, with metalophid and tritolophid and a pair of posterior cones only. Measurements: ap. 105e mm., tr. 58 mm., height of tritolophid 41e mm. Horizon and Locality.—Two miles west of Chinji Bungalow, India, 600 feet above base of Lower Siwaliks, Lower Chinji horizon, Mio-Pliocene. Type Figure.—Osborn, *op. cit.*, 1929.797, p. 5, fig. 6.

Specific Characters.—Small, very primitive; rudiment of external trefoil conule in valley between meta- and tritolophids; two small characteristic cones rising on posterior cingulum, as in *Serridentinus serridens;* lophs low and simple, barely subdividing into conelets; breadth of tritolophid 65 mm. as compared with 79 mm. in *S. serridens;* height of tritolophid 41e mm. as compared with 61 mm. in *S. serridens.*

Osborn, 1935: This single fractured type specimen reveals the presence in India of an ancestral phase of *Serridentinus* much more primitive than *S. mongoliensis* of the Lower to Middle Miocene of Mongolia and more primitive than the *S. proavus* of the Upper Miocene of Colorado; it is also much more primitive than the *S. subtapiroideus* of Eibiswald, Styria. Consequently it appears to be the most primitive species of *Serridentinus* thus far discovered.

11. SERRIDENTINES OF JAPAN AND CHINA, MIOCENE AND PLIOCENE

The type of '*Hemimastodon*' [=*Serridentinus*] *annectens* Matsumoto (Fig. 421) should be compared with the type of *Trilophodon sendaicus* Matsumoto as described and figured under *Trilophodon* (Longirostrinæ, Chap. VIII, fig. 226). This type lacks the strong 'central conules' which characterize *Trilophodon.* Consequently *H. annectens* is described in the present chapter under the genus *Serridentinus;* the true relationships of *S. annectens* and *T. sendaicus* can be settled only by the discovery of complete jaws.

Serridentinus annectens Matsumoto, 1924

Figure 421

From Banjôbora, Kaminogô-mura, Kani District, Province of Mino, Japan. Hiramaki formation, probably Burdigalian, Lower Miocene.

As shown in Chapter VIII (*Trilophodon*), the genotypic species of *Hemimastodon* (i.e., *H. crepusculi* Pilgrim) belongs among the Suina. The present species is placed under the genus *Serridentinus* to which it appears to be closely related.

The blunt, brachyodont cones and conelets of *S. annectens* (Fig. 421) compare closely with those of *S. browni* (Fig. 416) of the Chinji Siwaliks.

Hemimastodon annectens Matsumoto. Journ. Geol. Soc. Tôkyô, Vol. XXXI, 1924, p. 405 (1924.4). Supplementary Description.—Reprint Sci. Rept. Tôhoku Imp. Univ., Second Series (Geology), Vol. X, No. 1, 1926, pp. 1 and 4. Type.—Fragment of skull, bearing P^4-M^3 of right side and M^{2-3}, besides alveoli of P^4 and M^1, of left side *in situ.* Horizon and Locality.—Banjôbora, Kaminogô-mura, Kani District, Province of Mino, Japan. From a bed of fine, tufaceous sandstone of the Hiramaki formation. Probably Burdigalian, Lower Miocene. Type Figure.—Matsumoto, 1926.1, Pl. I, figs. 1 and 2, Pl. II, figs. 1, 2, and 3.

Matsumoto states in his supplementary description of 1926 (p. 4) that the skull is crushed down from above, so that its measurement, with the exception of the palate and cheek-teeth, cannot be accurately taken. The length of the skull fragment as preserved is given as 330 mm. The teeth measure as follows (in mm.):

	ap.	tr.	I.
Right P^4	36	38	105+
Right M^1	59	52	88
Right M^2	93	62	67
Left M^2	94	63	67
Right M^3	96(?)	69	
Left M^3	116	68	69
United length of M^{1-3}			268±

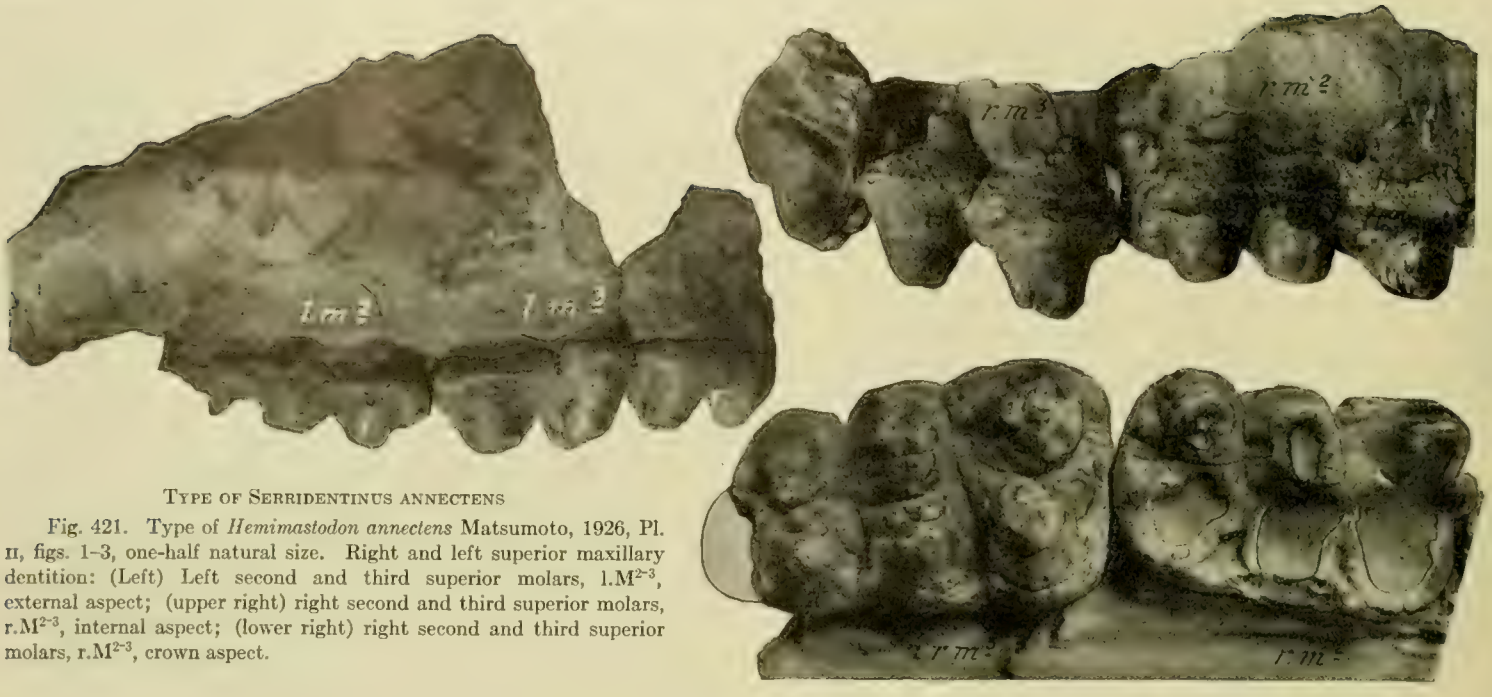
Matsumoto concludes (1926.1, p. 6) as follows: "The present species is evidently one of those with most primitively structured molars, of the post-Phiomian Bunomastodonts and is of course near the genotype, *Hemimastodon crepusculi* (Pilgrim), . . . of the Gaj of India. The M^3 of the present species is distinctly larger and especially longer than that of the Indian form, and its second ridge to the posterior talon are distinctly stronger. Consequently, the present species stands just between the Indian form and *Trilophodon angustidens typicus* in the limit of the dental characteristics."

Serridentinus lydekkeri Schlosser, 1903 (1906)

Figure 422

Red clays, Lower Pliocene(?), Shansi(?), North China.

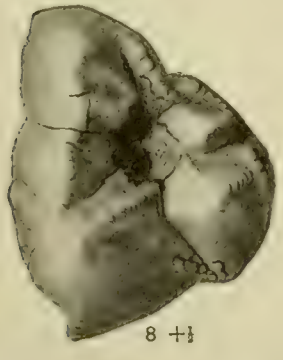
This fragmentary tooth of North China described by Schlosser in 1903 (1906) as *Mastodon lydekkeri* is probably referable to the genus *Serridentinus*, because in the entire absence of central conules it cannot be related to *Trilophodon* in which the central conules are always prominent. The fragmentary crest preserved



TYPE OF SERRIDENTINUS ANNECTENS

Fig. 421. Type of *Hemimastodon annectens* Matsumoto, 1926, Pl. II, figs. 1–3, one-half natural size. Right and left superior maxillary dentition: (Left) Left second and third superior molars, l.M^{2-3}, external aspect; (upper right) right second and third superior molars, r.M^{2-3}, internal aspect; (lower right) right second and third superior molars, r.M^{2-3}, crown aspect.

(Fig 422) resembles the tritoloph or tetartoloph of a third left superior molar of *Serridentinus chinjiensis* in the presence of a trefoil spur on the enlarged internal cone (compare Fig. 419); it differs widely from the type of *Stegolophodon latidens* in which the internal cones are smooth, rounded, and not enlarged.



TYPE OF SERRIDENTINUS LYDEKKERI

Fig. 422. Type of *Mastodon Lydekkeri* Schlosser, 1903, Taf. XIV, fig. 8, from the Röthliche Sande = Tientsin, Honan, North China, presumably a left M^3.

Schlosser designated this species from the posterior portion of a very large molar tooth, presumably a left M^3. From the entire absence of intermediate conules, he compared this tooth with *Mastodon latidens*. Excerpts from his type description are as follows:

Mastodon Lydekkeri Schlosser, 1903. "Die fossilen Säugethiere Chinas." Abhandl. der k. bayer. Akad. Wiss., Cl. II, Bd. XXII, Abth. I, 1903, pp. 46, 47. TYPE.—Presumably a left M^3. TYPE FIGURE.—*Op. cit.*, 1903, Taf. XIV, fig. 8. HORIZON AND LOCALITY.—Röthliche Sande = Tientsin, Honan, etc., North China. Lower Pliocene (?). (Granger, December, 1924): "It is not possible to give the exact locality of this type (*M. lydekkeri*); it probably comes from the red clays of the Lower Pliocene (*Hipparion* fauna) and fossil deposits in this horizon have been worked by Dr. J. G. Andersson in the provinces of Honan, Shansi, Shensi, and Kansu. These localities of Andersson are mostly old Chinese workings and doubtless a large part of Schlosser's Lower Pliocene fossils came from these very deposits. I would suggest using the term 'North China' as the locality for this type."

TYPE DESCRIPTION AND CHARACTERS (SCHLOSSER, 1903, P. 46).—"Eine neue Mastodonart wird angedeutet durch ein Fragment eines sehr grossen Molaren, vermuthlich des rechten oberen M_3 [M^3]. Es stammt, wie das noch anhaftende Gestein zeigt, aus den röthlichen Sanden und ist so vollkommen wie möglich petrificirt. Seine Farbe ist ein lichtes Graugrün. In den Vertiefungen sitzt ziemlich dickes, schwarzgefärbtes Cement. . . . . Leider ist nur ein Joch und der Talon vorhanden. Das Joch besteht aus einem sehr grossen Aussenhöcker und einem wesentlich kleineren Innenhöcker. . . . Auch dieser Zahn schliesst sich in Folge der vollkommenen Abwesenheit von Zwischenhöckern an *Mastodon latidens* an, aber die Anwesenheit von Cement und das Vorhandensein der erwähnten Kämme auf den Aussenhöckern sowie die Gedrungenheit des Talon verbieten die Identificirung mit *Mastodon latidens*. . . . Es wäre nicht ausgeschlossen, dass der bei *Mastodon* aff. *latidens* erwähnte kleine Prämolar, das Original zu Taf. XIV, Fig. 9, zu *Mastodon Lydekkeri* gerechnet werden dürfte."

Osborn, 1924: It is very difficult to determine the relationships from this fragment, but we are inclined to regard it as resembling a molar of *Serridentinus* rather than of *Trilophodon* or of *Tetralophodon*, owing (1) to the decided enlargement of the internal cone, (2) to the anterior and posterior spurs on the internal cone, rudimentary (?) lateral trefoils, and (3) to the entire absence of central conules or trefoils.

Serridentinus wimani Hopwood, 1935

Kansu, probably of Middle Miocene (Sarmatian) age.

Described by Hopwood as *Trilophodon wimani;* referred by Osborn, in the Appendix to the present Volume I, to *Serridentinus wimani*.

12. FLAT-TUSKERS OF CENTRAL ASIA AND WESTERN AMERICA (PLATYBELODON AND TORYNOBELODON)

Subfamily: **PLATYBELODONTINÆ** Borissiak, 1928

Subfamily Characters.—(Borissiak, 1928, p. 119): "The Subfam. *Platybelodontinæ* n. nom. (the name referring to the flat inferior incisors) arisen from the spoon-jawed representatives of *Phiomia*."

(Borissiak, 1929.1, p. 32): "The peculiar direction in the adaptation of similar forms which have apparently not hitherto been ascertained simply because of the highly fragmentary condition of the remains (mainly in the form of detached teeth), should be emphasized by these forms being separated into a distinct subfamily *Platybelodontinæ*."

In the above historical review of the 'shovel-tuskers' (pp. 328, 332–338), it was at first assumed by Osborn (1931) that the Amebelodontidæ Barbour, 1927 (modified to Amebelodontinæ in 1929) preoccupied the Platybelodontinæ Borissiak, 1928, both subfamilies possessing large shovel tusks penetrated by dentinal tubules. At that time (1931) it was not known that the lower grinding teeth (Fig. 441) of *Platybelodon* were of partial *serridentine* pattern, in widest contrast to the trilophodont pattern of the *Amebelodon* grinders. The working out of the rich collection of fifty mandibles and palates, young and old, revealed a very marked resemblance to the grinders of the Serridentinæ, as shown in *Ocalientinus* (*Ser.*) *floridanus* (Figs. 379, 380), in fact, the highly progressive serridentine pattern of the grinders of *Platybelodon* is clearly portrayed in the drawing (Fig. 441). Another striking contrast of *Platybelodon* to the *Trilophodon-Amebelodon* group is the presence of four ridge-crests in the second superior and inferior grinding teeth, as shown in figures 439 and 441. This adds new generic characters (see below) to those originally assigned to *Platybelodon* by Borissiak in his description of the genotypic species *P. danovi* (1928, p. 120) and by Osborn in his description of the type of *Platybelodon grangeri* (1929.769, pp. 2–16, and 1931.847, pp. 1–12).

We are now in a position to write in full the ridge-crest formula of *Platybelodon grangeri*, as follows:

$$\text{Dp}\,2\,\tfrac{2\cdot2}{2} \qquad \text{Dp}\,3\,\tfrac{3}{3} \qquad \text{Dp}\,4\,\tfrac{3\frac{1}{2}\text{-}4}{3\frac{1}{2}\text{-}4} \qquad \text{M}\,1\,\tfrac{3\text{-}3\frac{1}{2}}{3\text{-}3\frac{1}{2}} \qquad \text{M}\,2\,\tfrac{4}{4} \qquad \text{M}\,3\,\tfrac{5\frac{1}{2}}{6\frac{1}{2}}$$

Finally, the tusks in the Platybelodontinæ (*Platybelodon* and *Torynobelodon*) contain dentinal rod-cones, whereas in the Amebelodontinæ the tusks are composed of concentric laminæ.

Osborn, 1935: The related American genus *Torynobelodon* (genotype *T. loomisi*), the 'dredge-tusker' of Barbour, is fully described above on pages 338 and 339 of Chapter VIII.

Genus: **PLATYBELODON** Borissiak, 1928, 1929

Original reference: Ann. Soc. Palćont. Russie, VII, p. 120 (Borissiak, 1928.1).
Genotypic species: *Platybelodon danovi* Borissiak, 1928, p. 120.
See *Paraplatybelodon* Frick, 1933, p. 592, a provisional name.

Generic Characters.—(Borissiak, 1928, p. 120): . . . "upper jaw with flat and wide fore part, incisors reduced and not reaching the front border of the jaw; the mandible with long and wide spoon-shaped symphysis, the incisors being wide and flat; the bunolophodont cheek teeth show a ridge-formula similar to that of *Trilophodon* but somewhat more complicated."

(Borissiak, 1929.1, p. 32): "The peculiar features in the structure of the form described, which do not conform to the diagnosis of any known genus, that of *Phiomia* included, afford grounds for regarding it as a distinct genus; in concordance with other generic names of Mastodonts as also in view of the shape of the lower tusks this genus could be given the name of *Platybelodon*. It may be characterized as possessing a mandible with a very well developed symphysis of a wide spoon-like shape corresponding with the wide and flat lower tusks, and an upper jaw provided with small tusks, its flat and wide anterior end projecting beyond the distal ends of these tusks; the grinding teeth of a complex bunolophodont type."

ADDITIONAL GENERIC CHARACTERS (OSBORN, 1935) OF PLATYBELODON

(1) Fourth superior and inferior deciduous premolars and second molars with four ridge-crests instead of three ridge-crests as in *Amebelodon* and *Serbelodon*. (2) Strongly developed serridentine molar pattern broadly resembling that of *Ocalientinus* (*Ser.*) *floridanus* and demonstrating clear subfamily distinction from *Amebelodon* in which the superior and inferior molars are of the *Trilophodon* pattern and the tusks contain dentinal laminæ, whereas the *Platybelodon* tusks are composed of dentinal rod-cones. (3) It now appears that *Platybelodon* is an offshoot of the Serridentinæ rather than of the Amebelodontinæ as originally supposed. (4) Intermediate molar pattern differing from M 3 as in *Serridentinus*. (5) M 3, serrate trefoils on anterior face only.

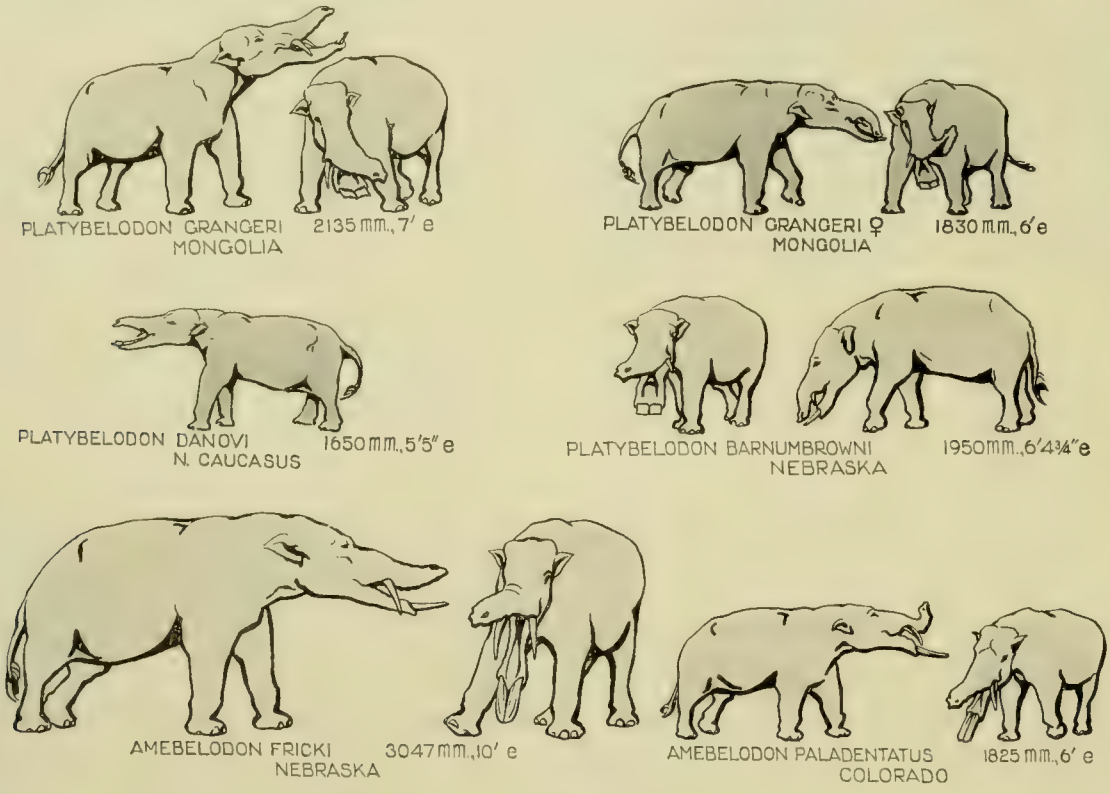


Fig. 423. Restoration (1932) of the Amebelodont Shovel-tuskers and the Platybelodont Flat-tuskers of Mongolia, North Caucasus, Nebraska, and Colorado

By Margret Flinsch, under the direction of Henry Fairfield Osborn

Uniform scale of one-hundredth natural size

Platybelodon grangeri Osborn, 1929. Male (left) after type skull and jaws (Amer. Mus. 26200), referred jaw (Amer. Mus. 26460), and referred female skull and jaw (Amer. Mus. 26462), with an estimated shoulder height of 2135 mm. or 7 ft.

Female (right) after referred skull and jaw (Amer. Mus. 26462), with an estimated shoulder height of 1830 mm. or 6 ft.

Specimens from the Upper Miocene Tung Gur tableland, Mongolia.

Platybelodon danovi Borissiak, genotypic species discovered in the Kuban region, North Caucasus. Estimated height 1650 mm. or 5 ft. 5 in.

Platybelodon[1] *barnumbrowni* Barbour, 1931. This species consists of a mandible in the Nebraska State Museum (1–10–7–31), found in Pliocene gravels on Snake River, Cherry County, Nebraska. Estimated height 1950 mm. or 6 ft. 4¾ in.

Amebelodon fricki Barbour, 1927. Based on a single lower jaw in the Nebraska State Museum (4–4–27), found near Freedom, Frontier County, Nebraska. Estimated height 3047 mm. or 10 ft. Middle Pliocene.

Amebelodon paladentatus Cook, 1922, first described as *Trilophodon paladentatus*. The restoration rests chiefly on the type lower jaw and tusk (Colo. Mus. 311) and two superior tusks of doubtful association (Colo. Mus. 314 and 315) showing enamel band on external surface. Estimated height 1825 mm. or 6 ft. Middle Pliocene of Wray, Yuma County, Colorado.

[1]Regarded by Osborn (1935) as belonging to Barbour's genus *Torynobelodon*.

CHIEF PALÆONTOLOGICAL AREAS EXPLORED BY THE AMERICAN AND RUSSIAN EXPEDITIONS OF KHOMENKO, BORISSIAK, AND ANDREWS IN EASTERN AND WESTERN ASIA NORTH OF THE 40TH PARALLEL.

DOTTED AREA INDICATES THE INTENSIVE EXPLORATIONS OF THE CENTRAL ASIATIC EXPEDITIONS OF THE AMERICAN MUSEUM OF NATURAL HISTORY (1922–1929). FAUNISTIC CORRELATIONS OF 1—11 BASED ON THE OBSERVATIONS OF KHOMENKO AND BORISSIAK. FAUNISTIC CORRELATIONS OF 1935 WILL APPEAR IN VOLUME II OF THE PRESENT MEMOIR.

Fig. 424. American (Andrews, 1922–1929) and Russian (Khomenko. 1912, Borissiak, 1929) explorations in eastern and western Asia. (Squares).—Permian Cretaceous Reptiles (1–14). (Circles).—Tertiary-Quaternary Mammals (5, 10–18) of the Khomenko and Borissiak explorations; (19, 20) of the Andrews explorations.

5. Ismaïl—Middle Pliocene. 10. Stavropol—Upper Sarmatic. 11. Belomechetskaja—Middle Miocene. *Platybelodon*. 12. Eldar—Middle Sarmatic. 13. *Indricotherium*, *Baluchitherium*—Upper Oligocene. 14. Jilančik—*Brachypotherium*, *Teleoceras*, *Serridentinus* [= *Trilophodon inopinatus*]—Lower Miocene. 15. Karaturgaj. 16. Ishim—*Paracamelus*—Upper Pliocene. 17. Semipalatinsk. 18. Pavlodar—Lower Pliocene. 19. *Serridentinus mongoliensis* of Loh; other Eocene to Pleistocene localities of the Altai region. 20. *Platybelodon grangeri* of the Tung Gur and other horizons of the eastern Gobi. Compare Osborn, 1930.832, fig. 1.

Platybelodon danovi Borissiak, 1928

Figures 286, 425–427, 428

Kuban region, North Caucasus. Chokrak beds, Middle Miocene (*fide* Borissiak), Upper Miocene (Osborn–Granger, 1931.847).

This stage is very important as the genotype of *Platybelodon*.

Platybelodon Danovi Borissiak, 1928. "On a new Mastodon from the Chokrak beds (Middle Miocene) of the Kuban region, *Platybelodon Danovi* n. gen. n. sp." Ann. Soc. Paléont. Russie, VII, pp. 105–120, Pl. VIII, figs. 1–4, text figs. 1, 2. January, 1928. TYPE.—"a fragment of skull with M^2-M^3 and with mandible." HORIZON AND LOCALITY.—"Chokrak-beds, Middle [Upper] Miocene, North Caucasus." Lower Pliocene. TYPE FIGURE.—*Op. cit.*, Taf. VIII, figs. 1–4. TYPE DESCRIPTION.—(*Op. cit.*, p. 120): . . . "upper jaw with flat and wide fore part, incisors reduced and not reaching the front border of the jaw; the mandible with long and wide spoon-shaped symphysis, the incisors being wide and flat; the bunolophodont cheek teeth show a ridge-formula similar to that of *Trilophodon* but somewhat more complicated."

SECOND DESCRIPTION

"On a New Direction in the Adaptive Radiation of Mastodonts," Palaeobiologica, 1929, Band II, pp. 19–33, Taf. III–V, text figs. 1–4.

TYPE (BORISSIAK, 1928, 1929).—Orbital, palatal, and maxillary portions of skull, with second and third superior molars of both sides, M^2, M^3; a nearly complete mandible with well-worn third inferior molars of both sides, M_3, second inferior molars recently shed (see reproduction of type figure in second description by Borissiak, 1929.1, Taf. III, figs. 1, 2, Taf. IV, figs. 1, 2, and Taf. V, figs. 1–3—Figs. 425, 426, and 427 of the present Memoir). Original in Leningrad Museum. HORIZON AND LOCALITY.—From the Kuban region, North Caucasus. Chokrak beds, Middle Miocene (*fide* Borissiak), Upper Miocene (Osborn-Granger).

TYPE DESCRIPTION (BORISSIAK, 1929.1).—After his brief characterization (January, 1928) with figures of the genus and species *Platybelodon danovi*, Borissiak published in 1929 ("Palaeobiologica, Band II, pp. 19–33) a complete and very important description of the 'flat-tusker' *P. danovi* discovered during the summer of 1927 in the Chokrak beds, which he regarded as Middle Miocene, of the Kuban region, North Caucasus. From this description not only are the type figures reproduced herewith but Borissiak's restorations of the head of *Platybelodon* (Fig. 428), which are of especial interest in comparison with the entirely diverse restorations of the head of *Amebelodon* by Barbour reproduced above (Figs. 292, 293, and 295).

After forwarding his manuscript to Palaeobiologica, Borissiak (1929.1, p. 33) received Barbour's prior description (June,

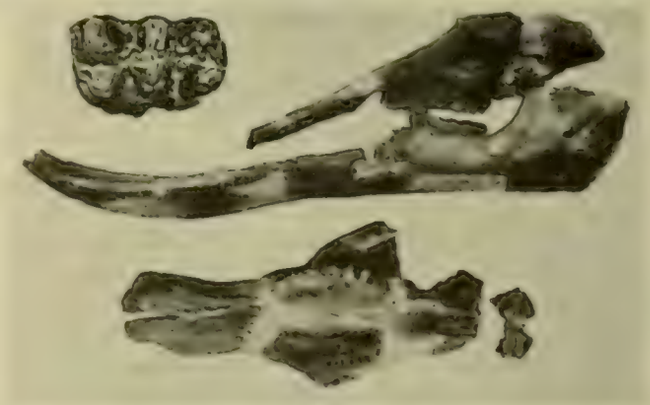


Fig. 425. *Platybelodon danovi* Borissiak, 1928. Type cranium and mandible, one-fourteenth natural size; also isolated molar, one-tenth natural size. After Borissiak, 1929.1, Taf. IV, figs. 1–3.

1927) of *Amebelodon fricki*, and in an Addendum to his paper Borissiak established the generic separation of *Platybelodon* from *Amebelodon;* he also conceded the priority of the subfamily name Amebelodontinæ Barbour to the subfamily name Platybelodontinæ Borissiak, 1928.

Characters (Borissiak, 1928, p. 120, 1929.1, pp. 19–33).—The type skull [a female] was found at some distance from the type mandible. M_3 only in place below, M^2, M^3 in place above; M^2 (100×65 mm.) with 3 ridge-crests, M^3 (133×65×41 mm.) with 4½ ridge-crests, M_3 (170×67×30 mm.) with 4 ridge-crests and talon [5½ ridge-crests—Osborn], single internal trefoils above, single external trefoils below, intermediate conules, with resemblance to *Phiomia wintoni*. Molars with great thickness of enamel. Superior tusks: Upper jaw provided with very small tusks, thickness 40 mm. [female—Osborn]. Mandibular rami low and massive, width 90 mm., height 105 mm.; symphysis very long (with tusks 700 mm.), expanding anteriorly, constricted posteriorly (130 mm.), forming a double channel, increasing in width (up to 245 mm.), forming a wide and rather deep (up to 50 mm.) spoon-shaped cavity, anterior end somewhat raised. (1929.1, p. 22): "The shape of the symphysis is due to the structure of the inferior tusks, which present a flat concave surface from above and are of a slightly spiral curved form in their distal part, while proximally (at the posterior margin of the symphysis, at the point of fracture of the jaw) they are normally elliptical in section, the long axis of the ellipse being set vertically. The greatest width of such a tusk attains 110 mm, its thickness along the middle line reaching 30 mm and along the outer side 25 mm, being but 15–20 mm at its anterior extremity; the bony sheath enveloping the tusk is 5 mm thick. The distal ends of the tusks meet one another in the middle line, while posteriorly (within the bone) they somewhat diverge. These distal ends have not been completely preserved. From the upper surface of the tusks enamel is absent; their anterior end is abraded by use throughout a length of about 100 mm, the remaining surface, being intact (denuded of the enveloping bone), bears irregular longitudinal grooves [dentinal rod-cones—Osborn]; below they are protected by enamel longitudinally striated."

Fig. 426. *Platybelodon danovi* Borissiak, 1928, genotype mandible. After Borissiak, 1929.1, Taf. III, figs. 1, 2. One-fourteenth natural size.

Functional Adaptation (1929.1, p. 30): "The above seems to indicate that this animal was driven in an opposite direction from the banks of the river to that followed by typical Mastodonts, in other words it fed and sought its safety from enemies in the water itself. To such a conclusion lead many other features in the structure of the animal, such as: the wide cup-like shape of the lower symphysis which contributed towards the retention of water plants from drifting away; an acceleration in the growth of complexity in the crowns of the molars in connection with the unusually rapid wearing out of the teeth, especially those of the mandible (food with a large amount of silt, from muddy water would first affect the lower jaw); lower tusks, probably exposed but a short distance beyond the mandible, not only slender, but having lost their coating of enamel from the upper surface; perhaps, an incipient modification in the structure of the skull displayed by the diminution of the orbit. The animal, as also its Lower-Tertiary ancestors, was deprived of a trunk and similarly to them continued to seize its food with its muscular upper lip, covering the mandible; the lower tusks against which the upper lip pressed its food mixed with sand and mud therefore wore out along their anterior end from above; possibly this upper lip recalled the wide fore part of the muzzle of the *Hippopotamus*, although much more lengthened out.

Fig. 427. *Platybelodon danovi* Borissiak, 1928. Type left third inferior molar, l.M_3, found *in situ*. Three-fifths natural size. After Borissiak, 1929.1, Taf. V, fig. 1. Observe M_3 with 5½ ridge-crests.

Neither had the animal probably acquired the large ear of the elephant [Footnote: 'See Osborn's note in his Classification of Proboscidea, Palaeont. Hungarica. v. I, 1921–1923, p. 41.']."

Comparative Measurements.—The detailed measurements scattered through the pages of Borissiak's article (1929.1, pp. 21–33) may be summarized and condensed in comparison with those of the species first named by Osborn and briefly described as *Amebelodon grangeri* (Osborn, 1929.769, pp. 12–16) and later (Osborn–Granger, 1931.847, p. 6) recognized as *Platybelodon grangeri*, as fully set forth below. The type of *Platybelodon danovi*, as noted above, is a female with very small tusks, whereas the

type of *P. grangeri* is probably a male, in which the tusks are considerably larger.

Measurements (Compare Osborn, 1931.847)	*Platybelodon danovi* Type, (?) Female	*Platybelodon grangeri* Type, Mandible Amer. Mus. 26200
Mandibular Measurements		
Mandible:		
Length, condyle to tip of incisor	?1240 mm.	1530e mm.
condyle to tip of median symphysis	1102e	1340e
Symphysis:		
Length, to tip of incisors	700	880
to symphyseal border	518	670
Breadth (maximum)	245	380–388
Breadth (minimum)	130	165
Mandibular ramus:		
Breadth, maximum (thickness)	90	106
Depth, maximum (height)	120	178
Dental Measurements		
Inferior incisive tusks:		
Breadth (width)	110 [108]	166
Thickness	15–30	ext. 25–33 med.
Third inferior molar, M_3		Paratype
Length	168–170	192–205
Breadth (width)	67	69–68
Height	30–25	70–69
Second superior molar, M^2		
Length	98–100	
Breadth (width)	65	
Third superior molar, M^3		
Length	130–133	
Breadth (width)	65	
Height	41	
Cranial Measurements		
Fragment preserved:		
Length, glenoid to tip of superior incisors	746	
occipital condyle to tip of premaxillaries (est.)	819	1120
Maxillo-premaxillæ:		
Length	310	
Breadth (maximum)	180	
Incisive tusk:		
Transverse breadth (thickness)	40	

The above disparity in size (1) may be partly sexual, for example, the type of *Platybelodon danovi* (a female), of *P. grangeri* (a male); (2) it is more largely due to a progressive enlargement and specialization of *P. grangeri*.

Specific Characters of Platybelodon danovi.—Maxillo-premaxillæ, flattened and broadened. Two superior grinding teeth functional in adult dentition, orbit above M^3; M^2 three crested, with typical bunolophodont intermediate conules, as in *Phiomia*. M^3 four crested, bunolophodont, with lophs and conelets of *Phiomia* type. Superior incisive tusks small, rounded, diameter 40 mm. *Mandible* with low and massive rami, greatly prolonged anteriorly and upcurved towards extremity of incisors; symphysis greatly elongated, gradually expanding from narrowest portion (130 mm.) to broadest terminal portion (245 mm.); inferior double tusks with flattened, slightly concave surface above, greatest breadth 110 mm., thickness along midline 30 mm., along thinner outer line 25 mm., taken anteriorly 15–20 mm., converging at tip, slightly separated at emergence from jaws, enamel absent on upper surface, with irregular longitudinal grooves, protected below by enamel [?dentine] longitudinally striated (1929.1, p. 22).

The above synopsis from Borissiak's admirable text and figures (Figs. 1–4, Pls. III–V) demonstrates the complete generic distinction

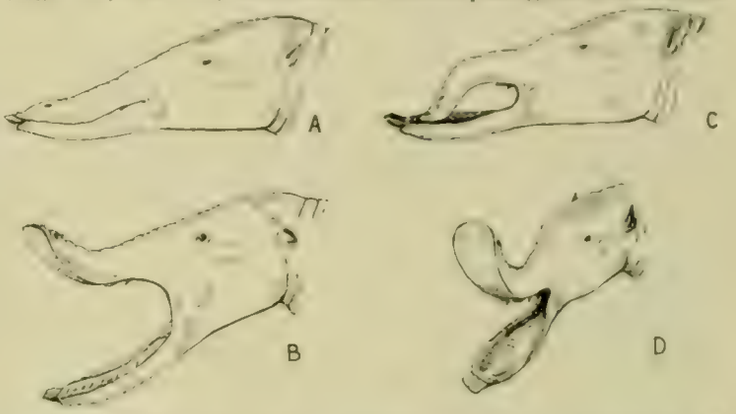


Fig. 428. Four restorations by Borissiak of the head, mouth-parts, and "muscular upper lip" of *Platybelodon*, each exhibiting the flat lower tusks, also the greatly reduced superior *female* tusks. After Borissiak, 1929.1, figs. 2 [A, B], 3 [C], 4 [D].

(A) The broadly flattened proboscis is appressed closely against the flat inferior tusks. (B) The flattened proboscis is raised, exhibiting the retreating tongue and small superior female tusks. (C) The flat proboscis is curved, rinsing and pressing back the plants from the trough into the mouth. (D) The flat proboscis is raised, the mouth is closed by the appression of the superior lips, thus enabling the animal to swallow its food.

of *Platybelodon* Borissiak (1928, 1929) from *Amebelodon* Barbour (1927); it also shows that the easterly Mongolian form discovered by Andrews and Granger in July, 1928, belongs to an entirely distinct species, to which Osborn in January, 1929, assigned the name '*Amebelodon grangeri*,' in honor of the discoverer, Walter Granger, to the type and referred specimens.

Platybelodon grangeri Osborn, 1929

Figures 286, 335, 429, 430, 433–439, 441, 444

Tairum Nor Basin, Mongolia. Tung Gur horizon, Upper Miocene. All specimens of *Platybelodon grangeri* have come from the Tung Gur tableland (Fig. 432). The original discovery of this form in 1928 was at N. Camp, and the type and best preserved specimen came from J. Camp. In 1930 the specimens came mostly from two quarries along the western escarpment.[1]

Amebelodon grangeri Osborn, 1929. "The Revival of Central Asiatic Life," Nat. Hist., Vol. XXIX, No. 1, Jan.–Feb., 1929 [issued January 29], pp. 2–16, figure (Osborn, 1929.769).

Platybelodon grangeri Osborn and Granger, 1931. "The Shovel-Tuskers, Amebelodontinæ, of Central Asia." Amer. Mus. Novitates, No. 470, April 10, 1931, pp. 1–12, text figs. 1–3 (Osborn, 1931.847).

Type.—Amer. Mus. 26200 (Field No. S12). Lower jaw, back

[1]See below (pp. 465–469) for full description, figures, and measurements of *Platybelodon grangeri*, based on the collections of 1930.

part weathered out; grinding teeth missing. A large fully adult individual. PARATYPE.—Amer. Mus. 26202 (Field Nos. 791, 792). Middle portion of right and left adult lower jaws, containing finely preserved second and third inferior molars of both sides, M_2, M_3. All measurements agree precisely with those of the type, consequently used in the restoration. HORIZON AND LOCALITY.—Tairum Nor basin, Mongolia. Tung Gur horizon, Upper Miocene. TYPE FIGURE.—Osborn, 1929.769, as *Amebelodon*, and Osborn and Granger (Osborn, 1931.847, figs. 1 and 3A, A1), as *Platybelodon grangeri*.

The comparative measurements above show that all the dimensions, mandibular and dental, of *Platybelodon grangeri*, including the lower molars, exceed those of *P. danovi* in the ratio of 5 to 4, this ratio being established by eight measurements common to both species, namely, *P. grangeri* 5249 mm., *P. danovi* 4145 mm. This average increment of *P. grangeri* over *P. danovi* of 5 to 4, however, is exceeded in the anterior part of the symphysis and in the incisors of *P. grangeri;* the ratio in this pre-mandibular region is as 8 to 5, or, from the three measurements in common, as 873 to 575; the pre-mandibular numerical ratio rises as follows:

MAXIMUM BREADTH OF ROSTRUM	*P. danovi*	*P. grangeri*
Symphysis	245	380
Single flattened incisor	110	166
Combined incisors at tip	220	327
	575	873

This establishes, as a clearly distinctive specific character of *Platybelodon grangeri*, its more progressive and highly specialized functional flat-tusk or platybelodont anterior region, namely, *the flat or shovel-tusk region evolves most rapidly since it has become vitally important in the struggle for existence.*

FIRST TYPE DESCRIPTION.—(Osborn, 1929.769, pp. 13–16): "A new species of mastodont named *Amebelodon grangeri*, a descendant of the primitive long-jawed mastodont (*Phiomia*) of northern Africa. Adapted to uprooting bulbous plants, it frequented the shallow lake waters of ancient Gobi. . . . This unique type of mastodont was first described by Prof. Erwin H. Barbour from a fossil jaw which he found in western Nebraska and to which he applied the highly appropriate generic name *Amebelodon* (derived from two Greek words signifying 'shovel' and 'end-tooth'). The Gobi discovery, which may be named *Amebelodon grangeri*, confirms in the most surprising manner the adaptation so aptly named by Professor Barbour, and it demonstrates, as in the case of all the other quadrupeds, that the Gobi climate and environment were even more favorable than that of the Nebraska plains in Pliocene time, because in the Gobi shovel-tusker the dimensions are nearly double those of the Nebraska shovel-tusker."

SECOND TYPE DESCRIPTION.—(Osborn, 1931.847, pp. 1–12): "Type exceeding *Platybelodon danovi* in size, mandibular dimensions in ratio of 5 to 4; in pre-mandibular dimensions in ratio of 8 to 5. Anterior portion of mandible greatly broadened; second inferior incisors correspondingly broadened, flattened, and relatively shortened; post-mandibular proportions as in *P. danovi*."

"SUPERIOR INCISORS.—The superior tusk-like incisors are relatively short and slightly out-turned; subcylindrical to cylindrical in section; slightly downturned, worn sharply at extremities (806A [1]). In the juvenile specimen (Amer. Mus. 26201), a female tusk not fully emerged presents at a point about 200 mm. from the tip a transverse measurement of 47 mm., and a vertical measurement of 48 mm. Whereas a supposed male tusk (806A [1]) presents at a point 204 mm. from the tip a transverse measurement of 47 mm., and a vertical measurement of 56 mm. The core of a still larger male tusk (806B [1]) presents a transverse measurement of 63 mm., and a vertical measurement of 70 mm., taken at the same distance."

Fig. 429. Type mandible of *Platybelodon grangeri* Osborn (Amer. Mus. 26200), in oblique superior and anterior aspects. About one-eighth natural size. After Osborn and Granger (Osborn, 1931.847, fig. 1).

Observe that the inferior incisors are accidentally separated; in the natural condition of the jaw (Fig. 286 A1) they are closely approximated, as indicated by dotted lines.

"MATERIALS.—Besides the type and paratype fully adult jaws there are four individuals represented by referred crania and jaws, several individuals represented by isolated fragments of inferior grinding teeth, six individuals represented by inferior incisive tusks, two individuals by superior tusks; five individuals represented by unassociated foot bones, which enable us to estimate approximately the height and bodily proportions of *Platybelodon grangeri*." In detail the materials collected in 1928 are as follows:

PORTIONS OF CRANIA AND JAWS.—Amer. Mus. 26202 (paratype). Amer. Mus. 26201, 26203, 26204, 26210, 26243, 26212 (referred).

[1]Field Nos. 806A and 806B now (1935) bear the following catalogue numbers: Amer. Mus. 26212A and 26212B.

Inferior Incisive Tusks.—Amer. Mus. 26200 (type). Amer. Mus. 26205, 26206, 26207, 26208, 26209, 26211 (referred).

Superior Incisive Tusks.—Amer. Mus. 26201, 26212 (referred).

Foot Bones.—Amer. Mus. 26212 (referred).

These dentinal rod-cones within the inferior incisive tusks were independently observed by Osborn in 1930. Figure 430A1, representing a partly fractured crown of Amer. Mus. 26207, shows a portion of this area and a mass of these dentinal rod-cones; these cones are seen also (A) in transection, each of which has a

MEASUREMENTS OF TYPE, PARATYPE, AND JUVENILE PLATYBELODON GRANGERI

	Amer. Mus. 26200 Type	Amer. Mus. 26202 Adult Paratype	Amer. Mus. 26201 Juvenile
Mandibular Measurements			
Total length	1340e mm. = 4 ft. 4¾ in.	1015+ mm. = 3 ft. 4 in.	980 mm. = 3 ft. 2½ in.
Symphysis:			
Length to end of alveolus	655e = 2 1½		415 = 1 4¼
Breadth (maximum)	388 = 1 3¼		229 = 9
Breadth (minimum)	165 = 6½		122 = 4¾
Ramus:			
Depth below M 2	150 = 5⅞	129 = 5 1/16	106+ = 4⅛
Breadth opposite M 2	111 = 4⅜	91 = 3½+	101 = 4

Dental Measurements	l.M_2	l.M_3	r.M_2	r.M_3	l.M_1	l.M_2	r.M_2	r.M_3
Anteroposterior	109	205	100	192	92e	123	125	?
Transverse	63	68	61	69	51	58	55	55+
Height	?	69	?	70	?	63	60	59e

INFERIOR INCISORS AND DENTINAL ROD-CONES

In the type (Fig. 429—Amer. Mus. 26200) the lower incisors, on excavation, were rightly estimated at 14 in. (360 mm.) in total length, of which the exposed portion measures exactly 8¾ in. (225 mm.); width 6½ in. (166 mm.); median thickness at point of exposure 1¼ in. (33 mm.); thickness along outer border 1 in. (25 mm.). Portions of five more or less fractured lower incisors reveal a very new and important character, namely, the presence of dentinal rod-cones, first reported (Dec. 20, 1929) by Barbour in his original description of the 'dredge-tusker' *Torynobelodon loomisi*, as fully set forth above (pp. 338 and 339).

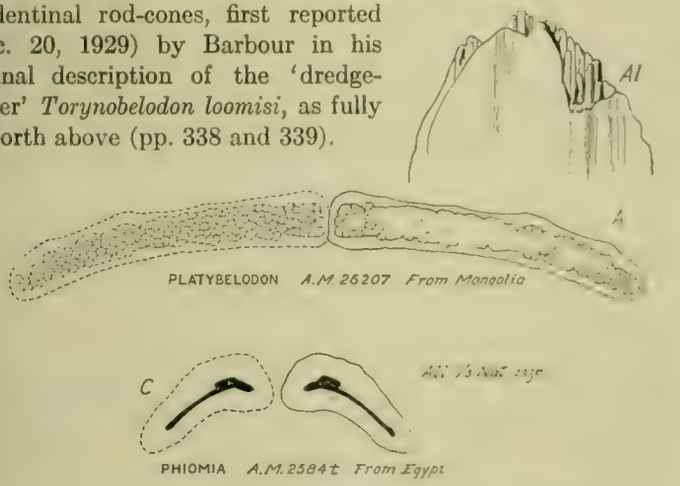


Fig. 430. Dentinal Rod-cones of Platybelodon and Hollow Incisors of Phiomia, after Osborn, 1931.847, Fig. 2.
All one-third natural size

A, Diagrammatic transection of the right lower second incisor of *Platybelodon grangeri* (Amer. Mus. 26207). The left lower incisor section is restored.

A1, Superior aspect of the right lower second incisor of same specimen (Amer. Mus. 26207) showing the partly exposed dentinal rod-cones.

C, Section of the right lower second incisor of *Phiomia osborni* (Amer. Mus. 2584t) from the Oligocene of the Fayûm, Egypt, exhibiting open dental pulp cavity. The left lower incisor is restored.

small lumen. This discovery led to the examination of a portion of a left lower incisor (Fig. 431B—Colo. Mus. 1319) from Texas, at first referred to *Amebelodon*, in which dentinal rod-cones and not dentinal laminæ are displayed, although the fossilization is much less clear and distinct, hence probably referable to *Platybelodon* (see Fig. 286E).

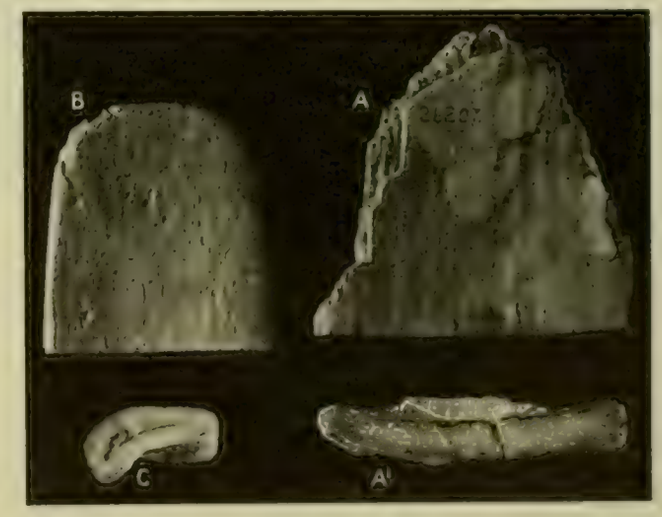


Fig. 431. Comparison of: B, *Platybelodon* ref. (Colo. Mus. 1319) from Texas, A, *Platybelodon* ref. (Amer. Mus. 26207) from Mongolia, A1, section of A, and C, section of *Phiomia* incisor (Amer. Mus. 2584t) from the Fayûm, Egypt. Compare opposite figure 430.

The dentinal rod-cones are very small and quite closely compacted in *Platybelodon* (A) and very numerous, namely, of an estimated total of 250 separate cones. The function of these rod-cones is certainly to strengthen the inferior tusks and to resist the results of abrasion of the beveled edges, as shown in figure 286 A1. The microscopic structure will be given further study.

FŒTAL, JUVENILE, AND ADULT GROWTH STAGES

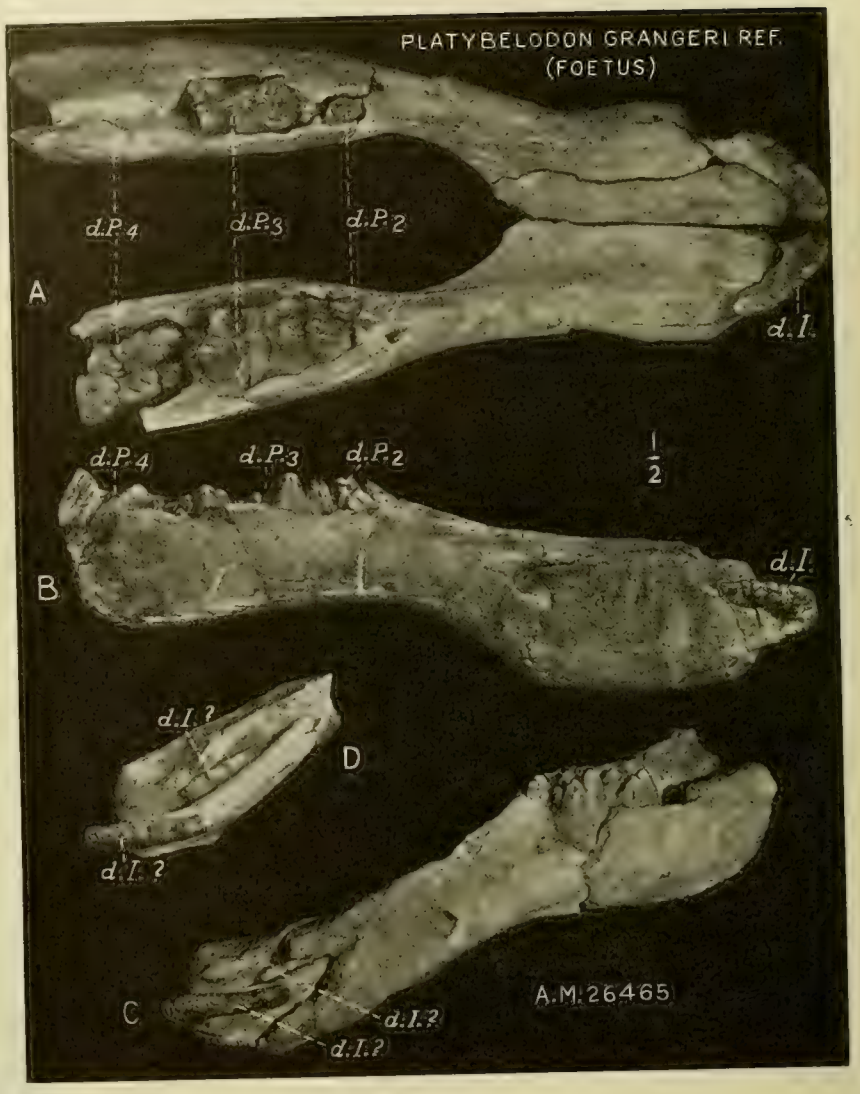
In addition to the type, paratype, and numerous other specimens of the 1928 collection (Amer. Mus. 26200-26212), the expedition of 1930 fortunately discovered two great quarries (Fig. 432) to the east of the Kalgan-Urga Trail which yielded an extraordinary assemblage of representatives of *Platybelodon grangeri* in all stages of growth from an unborn young, two juvenile stages, to adults of both sexes.

This unique collection amplifies the original descriptions of *Platybelodon* Borissiak, and extends our knowledge of *Platybelodon grangeri*, affording not only a complete definition of the species but greatly extended knowledge of the generic characters.

TUNG GUR HORIZON OF UPPER MIOCENE AGE, PLATYBELODON GRANGERI LIFE ZONE

These beds, discovered in 1928 by Andrews and Spock, occur as a low peneplaned tableland more than 25 miles across. The northwestern edge of this deposit lies about 40 miles southeast from Iren Dabasu on the Kalgan-Urga Trail. Near the edge of the tableland at this point is an important well, known to all travelers in the region as Gur Tung Khara Usu. The horizon name Tung Gur (Spock, 1929.1, p. 4) was derived by reversing the first two words of this name.

The beds are well exposed along the northern and western faces of the tableland and also for some distance along the southeastern face—bordering Tairum Nor, which latter place was worked in 1928, yielding the type of *Platybelodon grangeri*; this is the diagnostic species of the Tung Gur beds and occurs throughout the exposures.

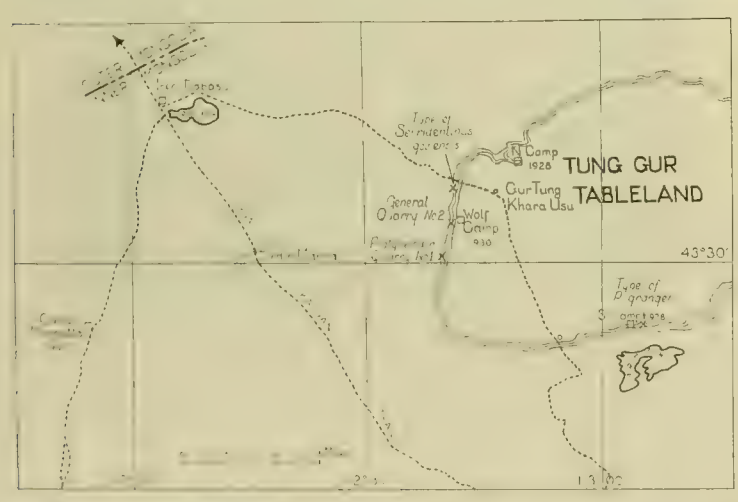


Deciduous Succession in Platybelodon

Compare the same in Trilophodon (Fig. 196) and Platybelodon (Fig. 435), also compare type of Phiomia serridens (Figs. 180, 181).

Fig. 433. Mandible and dentition of *Platybelodon grangeri* ref. (Amer. Mus. 26465). Quarry No. 2. After Osborn, 1932.886, p. 4, fig. 2. One-half natural size.

This very immature mandible is believed to be that of a fœtus, as it was found within the pelvis bones of an adult. It contains the milk dentition Di_2 to Dp_4 inclusive. A, Crown view; B, outer view of right ramus; C, diagonal view of left ramus; D, view of left incisors with bone removed.



Sketch Map of the Region Around Iren Dabasu, Inner Mongolia

Fig. 432. The two working camps of the 1930 Central Asiatic Expedition are here shown in Wolf Camp in the Upper Miocene (*Platybelodon*) beds of the Tung Gur tableland and Camp Margetts to the westward in the Upper Eocene (Irdin Manha) and mid-Oligocene (Houldjin Gravels). After Osborn and Granger (Osborn, 1932.886, fig. 1).

In 1928 the specimens of this genus were found more or less scattered, but in 1930 the majority of them came from two deposits or quarries which seem to have been bogholes in which the animals became mired. These two quarries were quite unlike in the fauna represented in them.

Quarry 1 (10 miles south of Gur Tung Khara Usu).

Yielded about 16 pairs of lower jaws of *Platybelodon*, 5 or 6 fairly complete skulls and a great quantity of skeletal material, a complete representation of which was saved. All but two or three of these Platybelodonts were adults, and there was almost nothing else in the quarry except this form.

Quarry 2 (5 miles south of Gur Tung Khara Usu).

Yielded portions of at least one adult *Platybelodon* and 7 or 8 very young individuals. One of the latter (Amer. Mus. 26465) is considered in a fœtal stage as it was taken out from between the two *os innominata* of an adult.

In addition to *Platybelodon*, this Tung Gur quarry yielded a great quantity of remains of smaller forms — rhinocerids, bovids of many sorts, carnivores, rodents, and horses (*Anchitherium*) — which remain to be identified.

LIST OF PROBOSCIDEAN MATERIAL FROM TUNG GUR BEDS IN THE 1930 COLLECTION

Platybelodon grangeri

Amer. Mus. 26460 Lower jaws (see Fig. 437). Quarry No. 1.
26462 Skull and lower jaws (see Fig. 436) and portion of skeleton of female. Isolated specimen.
26463 Upper incisor (see Fig. 436). Quarry No. 1.
—— A series of some 15 lower jaws and several skulls, together with much skeletal material. Quarry No. 1. Includes Amer. Mus. Nos. 26469–26472, 26474, 26475, 26479.
26464 Skull and lower jaws, juvenile (see Fig. 435). Quarry No. 2.
26465 Lower jaws and maxilla, tusk with enamel tip. Fœtal young (see Figs. 433, 434). Quarry No. 2.
—— Lower jaws and fragmentary skulls of 7 or 8 young individuals. Quarry No. 2. Unprepared and unnumbered.
26466 Maxilla and lower jaws. Isolated specimen.

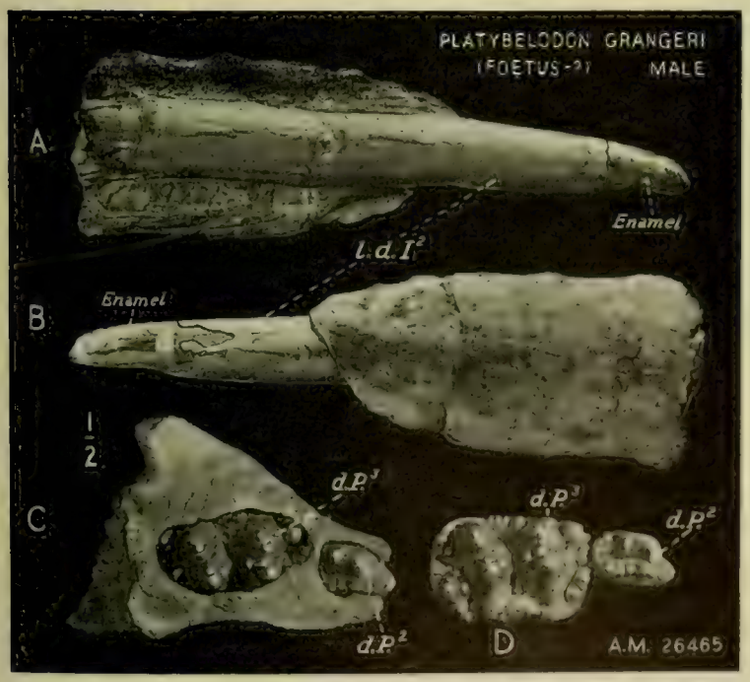


Fig. 434. Superior dentition of the same individual (Amer. Mus. 26465) as that represented in figure 433. After Osborn, 1932.886, p. 5, fig. 3, one-half natural size.

The teeth are identified as the superior milk incisor—A, inner, B, outer view; and premolars 2 and 3—C, showing teeth in alveoli, D, same teeth removed from alveoli.

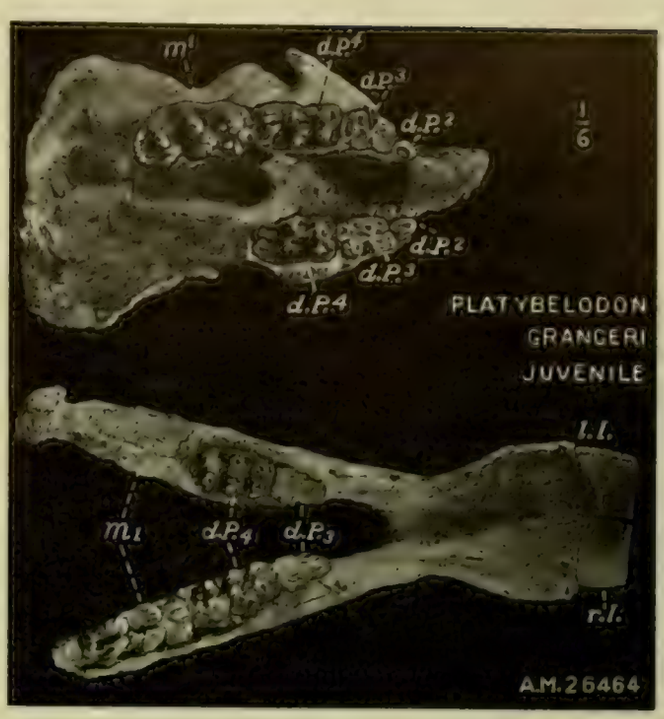


Fig. 435. Juvenile fragmentary cranium and nearly complete mandible of *Platybelodon grangeri* ref. (Amer. Mus. 26464). Quarry No. 2. After Osborn, 1932.886, p. 6, fig. 4, one-sixth natural size.

Containing the deciduous dentition and permanent M^1 and M_1 as indicated. The flattened incisors are indicated as r. I. and l. I. and for the present interpreted as being the tips of the large permanent incisors represented in the adult stage in figure 437 of the present Memoir.

26467 Lower jaws. Isolated specimen.
26468 Lower jaws, incisors, much worn M_3.
26473 Third right superior molar, r.M^3 (Fig. 439). Quarry No. 1.
26477 Baby skull and lower jaws, with dentition, found closely associated with Amer. Mus. 26462.
26478 Lower jaws, M_{2-3}, right and left M_3 unerupted; symphysis missing. Quarry No. 1. (Fig. 441.)
26479 Skull, r. and l. M^{1-3}, M^1 worn (Fig. 335).
26480 Skull, r. and l. M^{2-3} (Fig. 335).

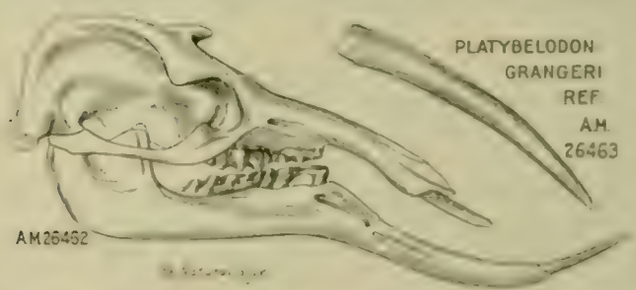


Fig. 436. Female *Platybelodon grangeri* ref. (Amer. Mus. 26462), an isolated specimen from the Tung Gur horizon, found with the cranium and jaws and parts of skeleton associated

Male superior tusk of *Platybelodon grangeri* ref. (Amer. Mus. 26463) from *Platybelodon* Quarry No. 1. Drawn to the same scale to show the marked disparity between the male and female tusks.

Both figures after Osborn, 1932.886, p. 11, fig. 7, one-fifteenth natural size

While the *Platybelodon* material in the 1928 collection was ample for generic reference and for specific determination, that of the 1930 collection is vastly greater, and when the preparation is finished will give complete knowledge of the skull, jaws, and skeleton. The most unusual feature of the 1930 collection is the series of specimens illustrating growth stages. These range from old adults down to very young or even fœtal specimens.

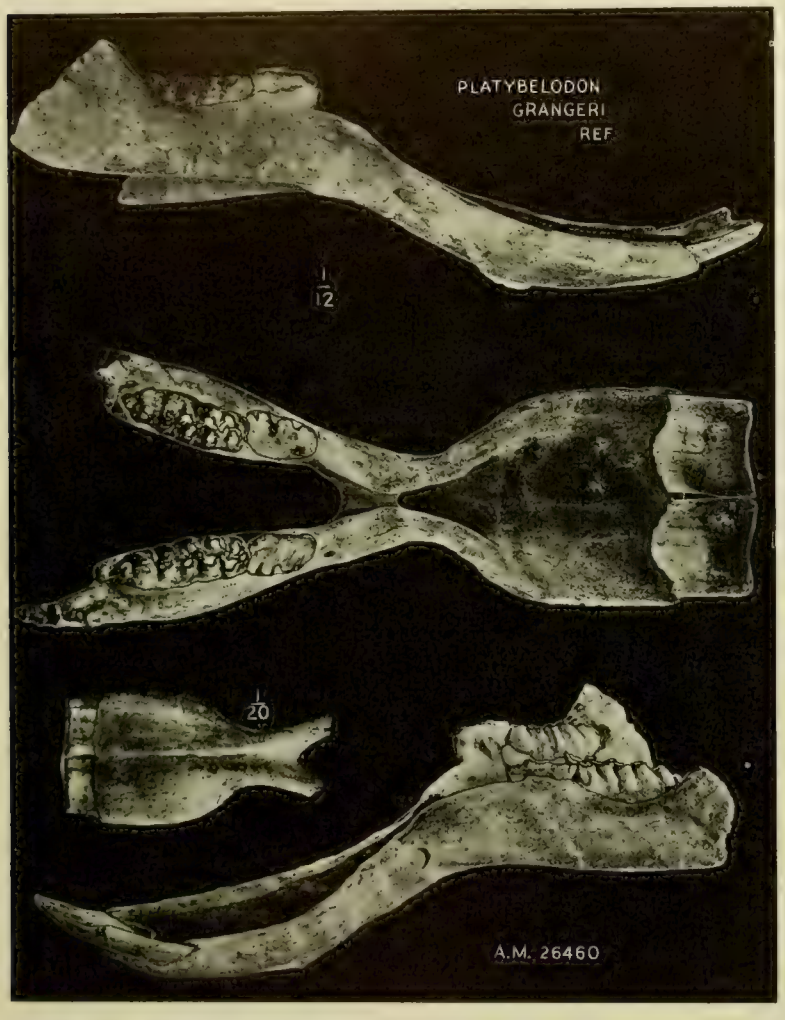


Fig. 437. Fully adult mandible and dentition of *Platybelodon grangeri* ref. (Amer. Mus. 26460). *Platybelodon* Quarry No. 1. After Osborn, 1932.886, p. 7, fig. 5. Superior and two lateral aspects, one-twelfth natural size. Inferior aspect of I_2, displaying the scissor-shaped lower surface, about one-twentieth natural size.

Fœtal Young.—(Figs. 433 and 434) This specimen, consisting of a pair of lower jaws, a maxilla, and a fragment of a premaxilla supporting the upper incisor, was found lying between the two halves of the pelvis of an adult *Platybelodon*, and this, coupled with the fact that none of the teeth is erupted, leads to the presumption that this was actually an unborn young. Some interesting characters are to be observed in this specimen which would be lost in an individual that had begun to use its teeth. Both upper and lower tusks are tipped with thin enamel which is indicated in the figure (Fig. 434) by darker coloring. The lower incisors present a scalloped anterior edge not perfectly shown in the reproduction. The presence of two incisors, one lying directly above the other and less advanced in growth, is a bit puzzling. It is presumed that the lower and more advanced one is a deciduous tooth. The upper one, which has a crown of about the same size as the other, may be a second deciduous incisor or possibly the germ of the permanent tooth. The anterior cheek tooth, above and below, is definitely the second deciduous premolar, as determined by working backward from an adult through a series of young individuals; in the lower jaw this is a simple peg-shaped tooth and was apparently lost early in the life of the individual.

Juvenile.—(Fig. 435) In this individual, which had probably attained the age of two years or more, the permanent lower incisor is already functioning and shows the characteristic bevel on the anterior edge. The first molar, above and below, is formed but not erupted. The second premolar is still retained in the upper jaw but has already been discarded in the lower jaw.

Adult.—(Figs. 437 and 438) The lower jaw of a fully adult animal with the M_3 in wear is uncrushed and exhibits in an admirable manner the profile of the ramus and the broad shovel-shaped symphyseal region. The bevel on the edges of the incisors is beautifully shown in this specimen. It seems probable that this bevel was produced by abrasion against a smooth rock or against the bottom of a shallow pond or stream in the process of scooping up vegetation, a process in which the broad, short trunk was used in connection with the mandibular scoop.

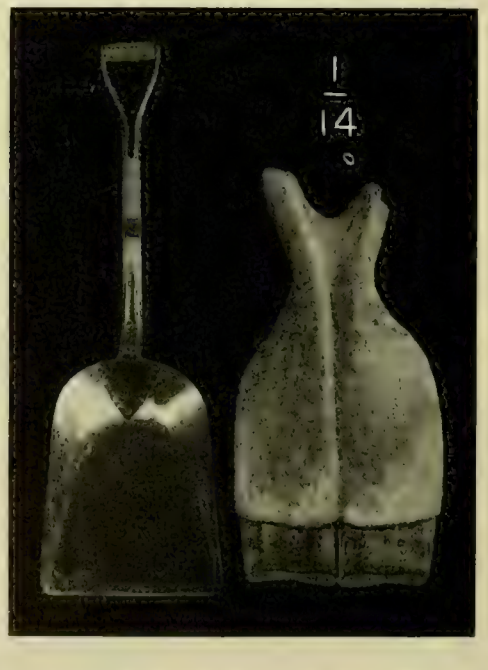


Fig. 438. *Platybelodon grangeri* ref. (Amer. Mus. 26460) anterior portion of the same mandible as in figure 437. After Osborn, 1932.886, p. 8, fig. 6, one-fourteenth natural size.

Inferior aspect of the lower pair of incisors, I_2, placed beside a coal shovel with the same transverse diameter as the anterior cutting portion of the inferior incisors, namely, fourteen inches.

PLATYBELODON: TUNG GUR BEDS, 1930

SUPERIOR MOLAR MEASUREMENTS (IN MILLIMETERS)[1]

	Fœtus A.M. 26465	Juvenile A.M. 26464	Young A.M. 26201	Old Adult A.M. 26462
Dp^2 ap.	25	23		
tr.	16	17		
h.	14	12+		
Dp^3 ap.	47	46		
tr.	30	34.5		
h.	24	20+		
Dp^4 ap.		75		
tr.		41		
h.		33		
M^1 ap.		101	115	
tr.		52 est.		
h.		50 est.		
M^2 ap.			imperfect	112+
tr.				70
h.				
M^3 ap.				184
tr.				?
h.				

INFERIOR MOLAR MEASUREMENTS (IN MILLIMETERS)

	Fœtus A.M. 26465	Juvenile A.M. 26464	Young A.M. 26201	Adult A.M. 26203
Dp_2 ap.	10			
tr.	6.5			
h.	9.5			
Dp_3 ap.	48	46		
tr.	32	32		
h.	26	?		
Dp_4 ap.		80		
tr.		39		
h.		35		
M_1 ap.		101	81+	
tr.		41	52	
h.		?	(much worn)	
M_2 ap.			124	118
tr.			62	63
h.			50+	(worn)
M_3 ap.			not	211
tr.			fully	76
h.			formed	78 approx.

INFERIOR INCISOR MEASUREMENTS (IN MILLIMETERS)

	Fœtus A.M. 26465	Juvenile A.M. 26464	Young A.M. 26201	Old Adult A.M. 26462
Di_2 ap.	82 approx.		Incisors	
tr. (at cutting edge)	25.5		not preserved	
I_2 ap.		140 est.		400 est.
tr. (at cutting edge)		56		175

[1]Amer. Mus. 26201 and 26203 are from the 1928 collection.

PLATYBELODON: SUPERIOR AND INFERIOR MOLARS.—The superior and inferior molars of *Platybelodon grangeri*, illustrated in detail in the accompanying figures 439 and 441 on the same one-half scale as the corresponding molars of *Ocalientinus* (*Ser.*) *floridanus* (Figs. 380 and 403), reveal the unexpected branching off of the Platybelodontinæ from the Serridentinæ, or at least closer relationship to the *Serridentinus* than to the *Trilophodon* molar pattern. As observed above, this unexpected relationship substantiates the subfamily Platybelodontinæ of Borissiak as quite distinct from the subfamily Amebelodontinæ of Barbour in which we observe grinders of the simple *Trilophodon* pattern.

The ridge formula of *Platybelodon grangeri*, as seen in these referred molars (Amer. Mus. 26473, 26478), is as follows: M 2 $\frac{4}{4}$ M 3 $\frac{5\text{-}6}{6\text{-}6}$.

The measurements of these exceptionally perfect grinders are:

					Height tetarto-lophid			Height meta-lophid
	ap.	tr.	I.		ap.	tr.	I.	
Amer. Mus. 26473, r.M^3					220	85	39	118 (inner side)
Amer. Mus. 26478, l.M_3					218	65	30	86.5 (outer side)
l.M_2	135	63	47	52				

As based on the entire collection, the ridge formula is:

Dp 1 $\frac{?}{?}$ Dp 2 $\frac{\text{not ridged}}{\text{peg-shaped tooth}}$ Dp 3 $\frac{2\text{-}3}{2\text{-}2\text{-}3}$ Dp 4 $\frac{3\text{-}3}{3\text{-}3}$ P 3 $\frac{\text{not ridged}}{\text{not ridged}}$ P 4 $\frac{2}{2}$ M 1 $\frac{3\text{-}3\text{-}3}{3\text{-}3\text{-}4}$ M 2 $\frac{4}{4\text{-}4\text{-}3}$ M 3 $\frac{5\text{-}6}{5\text{-}3\text{-}6\text{-}3}$.

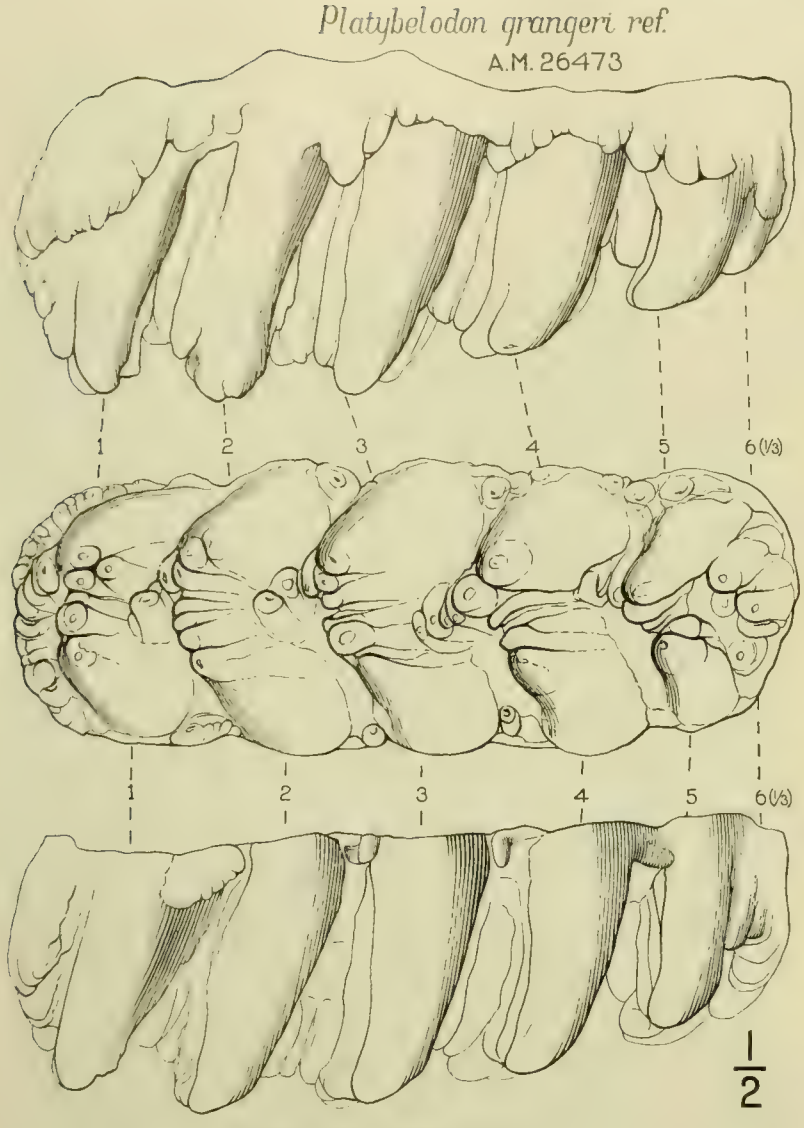
Superior molars with serrated *anterior* trefoil spurs of the entocones which abut against the center of the loph in front; unlike *Serridentinus* no posterior serrated spurs appear, thus the five entocones are smooth on the posterior faces, a sharp distinction from *Serridentinus*. The summits of the lophs are divided into conelets as follows:

Protoloph	5 conelets
Metaloph	8 conelets
Tritoloph	6 conelets
Hexaloph	5 conelets

As in *Ocalientinus* (*Ser.*) *floridanus*, the tall, relatively slender entocones of the superior molars (100 mm.) incline obliquely forwards; the tall, slender ectocones (92 mm.) also incline forwards.

Second Inferior Molar. Unlike *Trilophodon* this tooth is four crested, thus resembling *Tetralophodon* (Fig. 196).

Summing up the above molar characters, *Platybelodon grangeri* is decidedly progressive and specialized in grinding tooth adaptation to a succulent diet of bulbous aquatic plants. The lophs are more numerous than in the corresponding molars of *Ocalientinus* (*Ser.*) *floridanus* (Fig. 403), in which the ridge formula is M 3 $\frac{4\text{-}3}{5\text{-}4}$ as distinguished from $\frac{5\text{-}6}{6\text{-}6}$ in M 3 of *P. grangeri*. As clearly shown in the diagrammatic figures 439 and 441, the sharp distinction of *Platybelodon* is the *anterior* serration of the entocones in the superior molars and of the ectocones in the inferior molars, as distinguished from the double or anterior and posterior serration of the corresponding ento- and ectocones in the *Serridentinus* molars.



Superior Platybelodon Molar

Fig. 439. Right third superior grinder of *Platybelodon grangeri* ref. (Amer. Mus. 26473), one-half natural size. Five and one-third ridge-crests, forwardly inclined. Observe anterior serrated crests on the five entocones.

(Upper) External aspect. (Middle) Coronal aspect. (Lower) Internal aspect.

Type Description.—(Barbour, *op. cit.*, 1931.2, pp. 193, 195, 196): "The jaw of this scoop-tusker is relatively short and noticeably stocky. Width of scoop 12 inches. Length of mandible from condyles to tips of tusks, measured on the median line, 50 inches (1271 mm.). Length of mandible from condyles to the insertion of the tusks 41 inches (1042 mm.) . . . the tusks are broad, are roughly and deeply corrugated, and heavily worn by use, presumably in digging. This is confirmatory of the original conception that amebelodonts were elephants adapted to digging in mud, sand, or soft earth. Again it must be stated that the thinness of the jaw, its length as a lever and the smallness of the masseteric muscles seem at variance with this conception. Nevertheless this jaw must be an adaptation for digging. . . . The masseteric fossa is small and but slightly impressed, so the great chewing muscle must have been reduced in size. Altogether, the jaw seems inadequate mechanically. The ascending ramus is very low, like that of Eubelodon morrilli. Judging by the known position of the base of the incisors in Amebelodon fricki, the tusks in this mandible must be about 22 inches (559 mm.) long. Their width is 6¼ inches (160 mm.) and thickness about 1 inch (25 mm.). They bear a strong outward resemblance to the mandibular tusks of Torynobelodon loomisi. The tusks are sound and unbroken so it is not known whether or not sections would show the same dental tubules. Both molars are present and seem to be perfect, but at present are obscured by matrix and plaster cinches. They seem to be short but rather high-crowned."

Materials.—(Barbour, *op. cit.*, 1931.2, p. 191): . . . "three, probably four, skulls, more or less complete, with mandibles attached, and with perfect upper and lower dentition. Besides, there remain to be listed many skeletal parts such as ribs, vertebræ, limb bones, scapulæ, pelves, upper and lower tusks, molars and the like. Better still, there are probably three skeletons sufficiently complete to furnish in each case an authentic restoration."

Generic Comparison.—(Barbour, *op. cit.*, 1931.2, pp. 192, 193): "As far as the group is now known there seem to be three forms of shovel-tuskers, which are worthy of first attention. First, there are those having exceptionally long jaws and long straight mandibular tusks such as Amebelodon

Torynobelodon[1] **barnumbrowni** Barbour, 1931

Figures 440, 442, 443, and 445

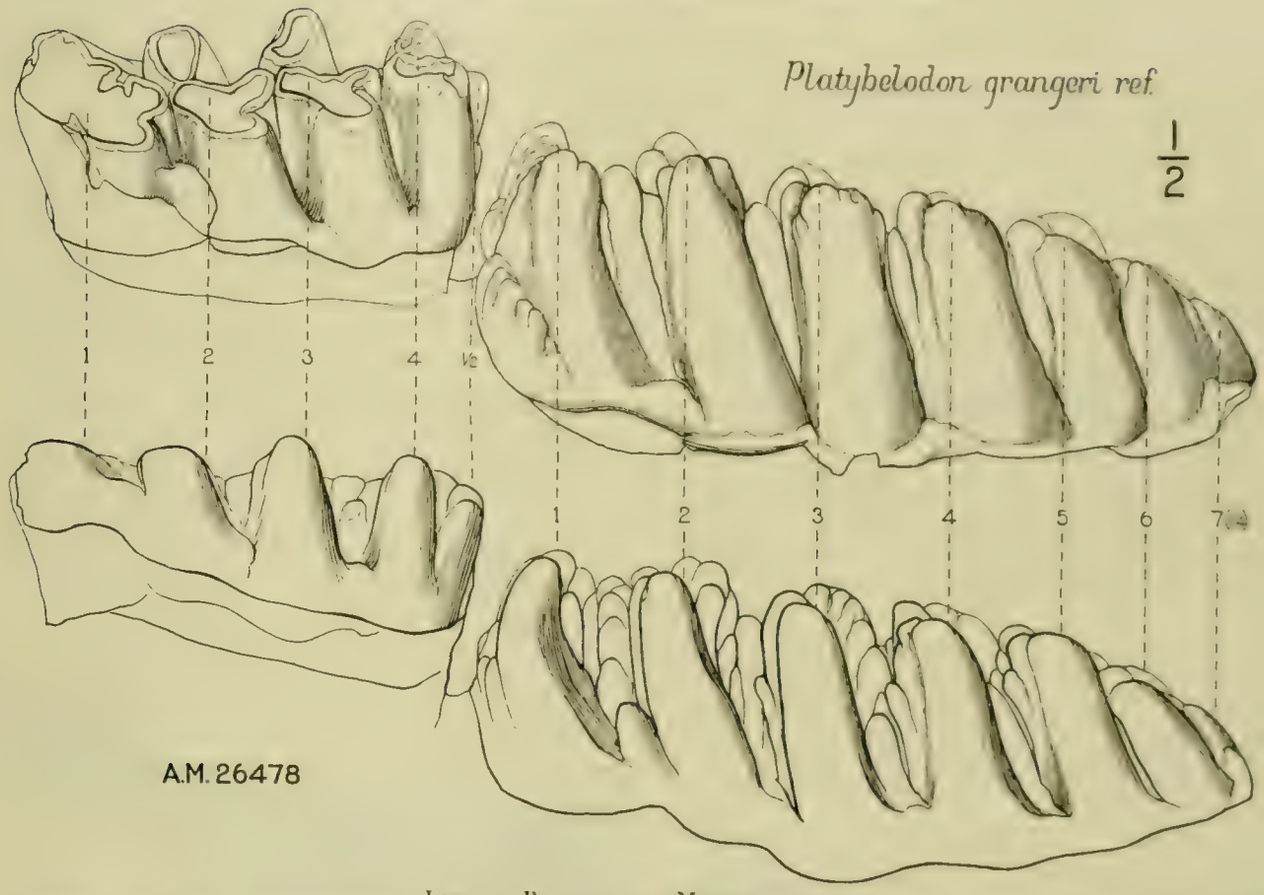
Pliocene gravels on Snake River, Cherry County, Nebraska.

Torynobelodon barnumbrowni Barbour, 1931. "A New Amebelodont, Torynobelodon barnumbrowni, Sp. Nov. A Preliminary Report." Neb. State Mus., Bull. 22, Vol. I, August, 1931, pp. 191–198, text figs. 123–126. Type.—Mandible with tusks and both molars present and apparently perfect, but at the time of description still obscured by matrix and plaster cinches. Neb. Mus. 1–10–7–31. Horizon and Locality.— . . . "dug out of Pliocene gravels on Snake River, Cherry County, 25 miles south-west of Valentine, Nebraska, July 1931, by Paul O. McGrew and Grayson Eichelberger, students in the University of Nebraska and student assistants in the museum." Type Figure.—*Op. cit.*, figures 123 and 124.

Type Mandible of Torynobelodon barnumbrowni Barbour

Fig. 440. "Torynobelodon barnumbrowni, ventral view of the mandible showing the great broad scoop and corrugated incisors of this remarkable scoop-tusked mastodont." Neb. Mus. 1–10–7–31, Morrill Coll. One-twelfth natural size. After Barbour, 1931.2, fig. 123.

[1]For full description of the genotypic species *Torynobelodon loomisi* Barbour, 1929, see Chapter VIII, pp. 338, 339.

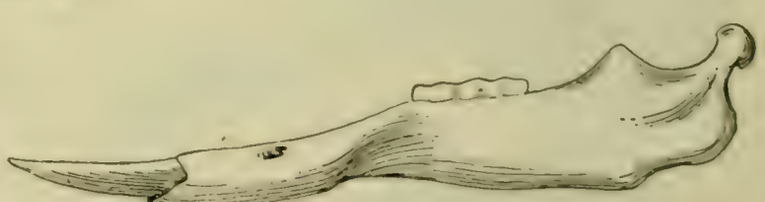


Inferior Platybelodon Molars

Fig. 441. Left second and third inferior grinders of *Platybelodon grangeri* ref. (Amer. Mus. 26478), one-half natural size. Six and one-fourth ridge-crests, forwardly inclined. Observe serrated crests on the six ectocones.

(Upper) External aspect of l.M_2, l.M_3. (Lower) Internal aspect of same.

fricki and A. sinclairi. Second, there is a group having shorter, broader jaws, with shorter, but broader and moderately curved tusks. These are the scoop-tuskers, or dredge-tuskers, Torynobelodon, so named because of a rough resemblance to these implements. Third, there is a group from the Gobi desert, similar to the last mentioned, having a relatively long slim jaw, which flares into a broad, deep scoop with tusks decidedly curved. The rare specimen under consideration seems to belong to the second group, and we are naming it Torynobelodon barnumbrowni. This mandible shows unmistakable Asiatic relationships, and it approaches Platybelodon grangeri of Osborn."



Type Mandible of Torynobelodon barnumbrowni Barbour

Fig. 443. "Torynobelodon barnumbrowni, side view, showing a straight, thin, stocky jaw with a very low ascending ramus. The tusks are short, about 22 inches, and are but very moderately curved. The under side of the tusk is in shadow, the edge in high light." Neb. Mus. 1-10-7-31, Morrill Coll. One-twelfth natural size. After Barbour, 1931.2, fig. 124.

Type Molars of Torynobelodon barnumbrowni Barbour

Fig. 442. Type left inferior molars of *Torynobelodon barnumbrowni* Barbour. After full-size pencil sketch by Professor Barbour of 4½ lobed l.M_3, and trilobed l.M_2. Reproduced one-third natural size.

Osborn, 1931: From the comparative measurements below as compiled chiefly by Barbour, it appears that the type of *Torynobelodon loomisi* is broadly similar in measurement to the female type of *Platybelodon danovi*. The incisive tusks in the type of *T. barnumbrowni* are similar in size to those in *Platybelodon grangeri*; the mandible of *T. barnumbrowni* is greatly abbreviated (1271 mm.) as compared with that of *P. grangeri* (1530e mm.), the rostrum of *T. barnumbrowni* (317 mm.) is similarly narrower than that of *P. grangeri* (380 mm.). The *female* type jaw (Fig. 425) of *P.*

danovi is smaller and exhibits less extreme specialization than the *male* type jaw of *P. grangeri*.

Osborn, 1932: Renewed comparison of the type of *Torynobelodon barnumbrowni* by Barbour and Osborn (August, 1932) indicates subfamily relationship to *Platybelodon grangeri*, as shown graphically in figures 444 and 445.

Comparative Mandibular Measurements (Barbour, 1931.2, pp. 195, 196)

	Platybelodon danovi. Female	*Platybelodon grangeri.* Male	*Torynobelodon loomisi*	*Torynobelodon barnumbrowni*
Breadth of single incisor	110 [108] mm.	166 mm.	114e mm.	159 mm.
Breadth (max.) of combined incisors	220 [216]	327	228e	321
Length of single incisor	?	?	?	559e
Total length condyle to tip of incisor	?1240	1530e	?	1271
Length of mandibular symphysis to tip of incisors	700	880	?	?
Breadth (max.) of mandibular rostrum	245	380–388	?	317
Breadth (min.) of mandible	?	?	?	241
Length of third lower molar, M_3	168–170	205	?	165

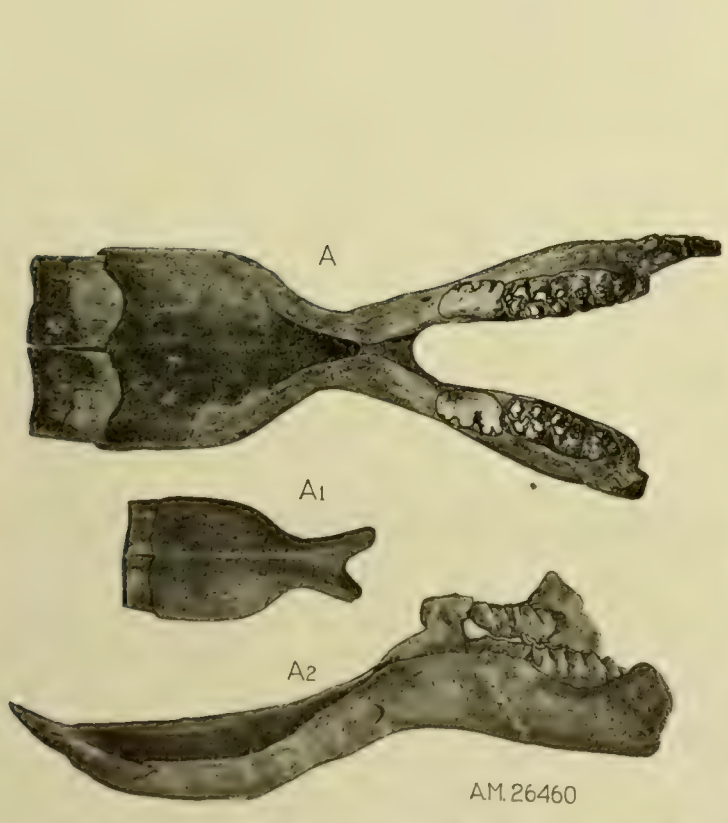


Fig. 444. Mandible of *Platybelodon grangeri* (Amer. Mus. 26460) in superior (A), lateral (A2), about one-thirteenth natural size, and inferior (A1) aspects, about one twenty-first natural size.

Observe the extreme broadening of the anterior portion of the rostrum for the accommodation of the very broad and closely appressed inferior shovel-shaped incisors; also the extreme constriction and narrowing of the mandibular groove, followed by the relatively slender rami bearing two grinding teeth. According to Gregory's theory (1934.1) the lower surface of the tongue occupies this narrow groove which broadens out into the deeply hollowed suprarostral concavity. Observe also the sharp, evenly worn incisors, with oblique chisel-shaped under surfaces, in contrast to the irregular wear of the *Torynobelodon barnumbrowni* incisors.

Fig. 445. Type mandible of *Torynobelodon barnumbrowni* Barbour to the same scale as *Platybelodon grangeri* opposite. First observe the irregularly fashioned and irregularly worn lower incisors, in contrast to the regularly and sharply defined borders of the lower incisors in *P. grangeri;* also the relatively narrow rostrum of the mandible and the relatively broad bar between the rostrum and the rami. Correlated with the less perfect functioning of the incisors in this species (*T. barnumbrowni*) is the larger size of the mandibular rami, both as seen from above and on the side (about one-thirteenth natural size).

Torynobelodon barnumbrowni appears to be a collateral branch, and somewhat less perfect mechanically, of the Platybelodonts of Central Asia.

APPENDIX TO CHAPTER X

Serridentinus filholi Frick, 1926, 1933

From Gers, France. Lower Miocene.

In reviewing the mastodonts in the Muséum d'Histoire Naturelle in Paris, Frick indirectly confirmed Osborn's observations that within the collections of the Paris and other European museums were representatives of two distinct phyla of long-jawed mastodonts, namely, of *Trilophodon* and of *Serridentinus*, as clearly defined in the present Memoir.

In 1926, Frick observed (Frick, 1926, pp. 177, 178) "I find . . . two widely differing species. . . . The second, heretofore unremarked and evidently rare form is represented alone by one well preserved mandible containing m_2, m_3, and tusks of both sides and the alveolus of m_1 . . . and the m_3 is much less elongate relative to m_2."

This "well preserved mandible" (Mus. d'Hist. Nat. Paris AC 2058 and 2062) becomes the type of a new species dedicated to Henri Filhol in the following type description:

(Frick, 1933, p. 509): "Note *Serridentinus filholi*, n.sp., from Gers, France." (*Op. cit.* p. 535): "The second, a heretofore unremarked and evidently rarer form, with noticeably shorter proportioned symphysis, is definitely represented by a well-preserved mandible containing m_2, m_3, m_1 alveolus and the tusks of both sides. In this specimen . . . the 'alveolar distance' (330 mm.) definitely exceeds the symphysial length (303 mm.), and the m_3 is much less elongate relative to m_2. The anteroposterior diameter of the (particular) m_3 is but slightly greater than that of the smallest m_3 of the extremely long symphysised form."

The above description, though brief, clearly points out as the generic distinction that the symphysis of this mandible is relatively shorter than in the *Trilophodon angustidens* phylum; also that the third inferior molar is relatively shorter than the corresponding molar in *T. angustidens*. The diagnosis leaves in doubt the crown structure of the *type*, that is, whether it is similar to that of *Serridentinus*. The measurements are as follows (Frick, letter, Sept. 6, 1933):

SERRIDENTINUS FILHOLI TYPE MANDIBLE (MUS. D'HIST. NAT. PARIS AC 2058, 2062)

Alveolar distance of M_1, M_2, M_3,	330 mm.
Length of mandibular symphysis	303
Breadth of mandibular symphysis	127

The individual is young, the first inferior molar, M_1, is represented only by a partial alveolus; the second inferior molar, M_2, is approximately 100 mm. in length; the third inferior molar, M_3, is 120 mm. in length and 58 mm. in breadth; breadth-length index = 48. These measurements indicate that the type is an animal much inferior in size to the genotypic specimen *Serridentinus productus* (Nat. Mus. 2346), in which the third inferior molar measures 164×76 mm., index 46, a close comparison being as follows:

	M_3		
	ap.	tr.	I.
Serridentinus productus type	164	76	46
Serridentinus filholi type	120	58	48

Serridentinus (Ocalientinus?) nebrascensis Osborn, 1924

Figures 394 and 446

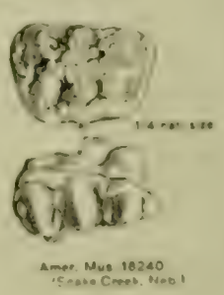
Lower Pliocene, Snake Creek B horizon; Snake Creek, Sioux County, Nebraska.

The Lower Pliocene *Serridentinus nebrascensis* of Snake Creek, Nebraska (Fig. 446), first erroneously identified by Osborn as *Stegomastodon*, proves to be a true Serridentine. The following description accordingly belongs to the Serridentinæ (present chapter).

This type molar (Figs. 446, 394), from the Lower Pliocene of Snake Creek, Nebraska, is distinguished by *double* trefoils. It is based upon one of the numerous isolated molar teeth (Fig. 394) found in the river drift deposits and requires confirmation by additional material; as shown in figure 394, the type (Amer. Mus. 18240) is identified as a first right superior molar, r.M^1, drawn in comparison with a referred first left superior molar, l.M^1 (Amer. Mus. 21459).

Stegomastodon nebrascensis Osborn, 1924. "Additional Generic and Specific Stages in the Evolution of the Proboscidea." Amer. Mus. Novitates, No. 154, December 24, p. 5. TYPE.—A first right superior molar, r.M^1 (Amer. Mus. 18240). HORIZON AND LOCALITY.—Lower Pliocene, Snake Creek B horizon, Snake Creek, Sioux County, western Nebraska. TYPE FIGURE.—Osborn, *op. cit.*, 1924.634, p. 4, fig. 2 B.

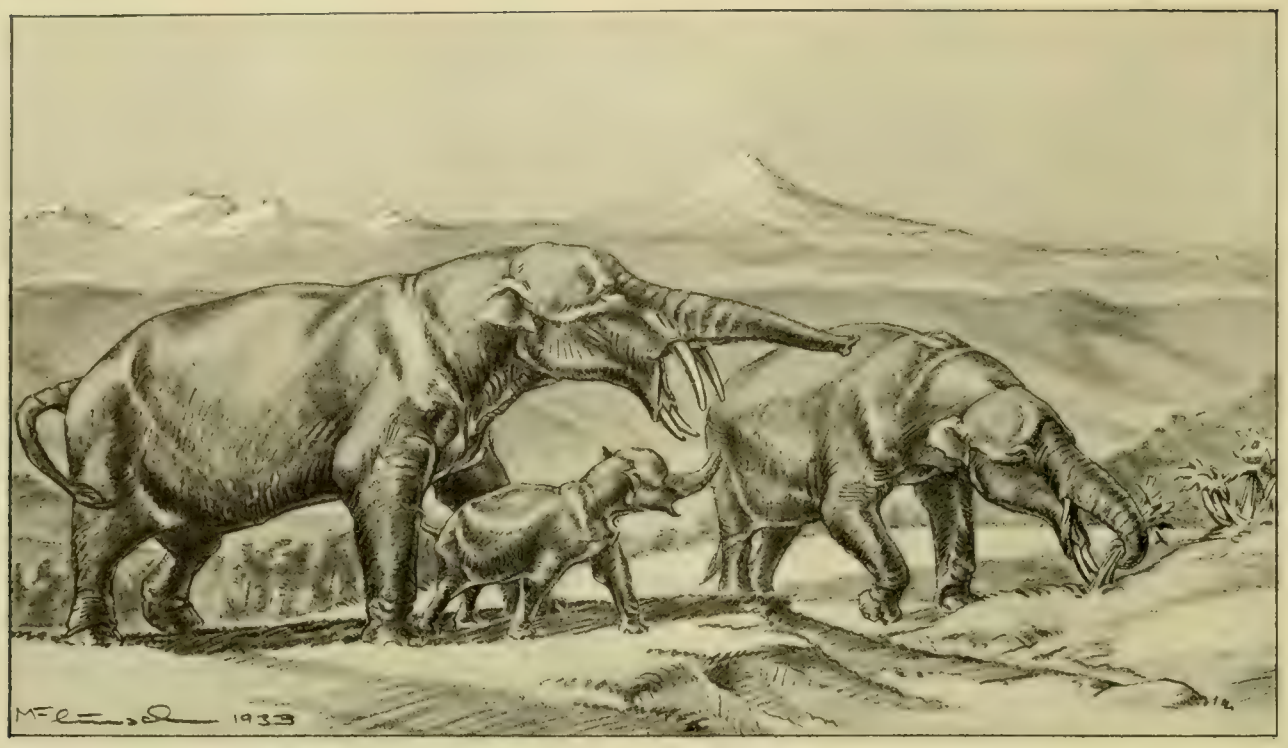
TYPE DESCRIPTION.—(Osborn, *op. cit.*, 1924.634, p. 5): "The type is apparently a first inferior molar of the right side [error, an r.M^1] and was collected in the river drift of the Snake Creek horizon. It exhibits the following characters: (1) cones closely compressed; (2) double external and internal trefoils; (3) broad crenulate external cingulum; (4) internal conelets arising from the internal cingulum in the internal and median valleys; (5) measurements as in figure 2B [Fig. 446 of the present Memoir].



TYPE OF SERRIDENTINUS NEBRASCENSIS

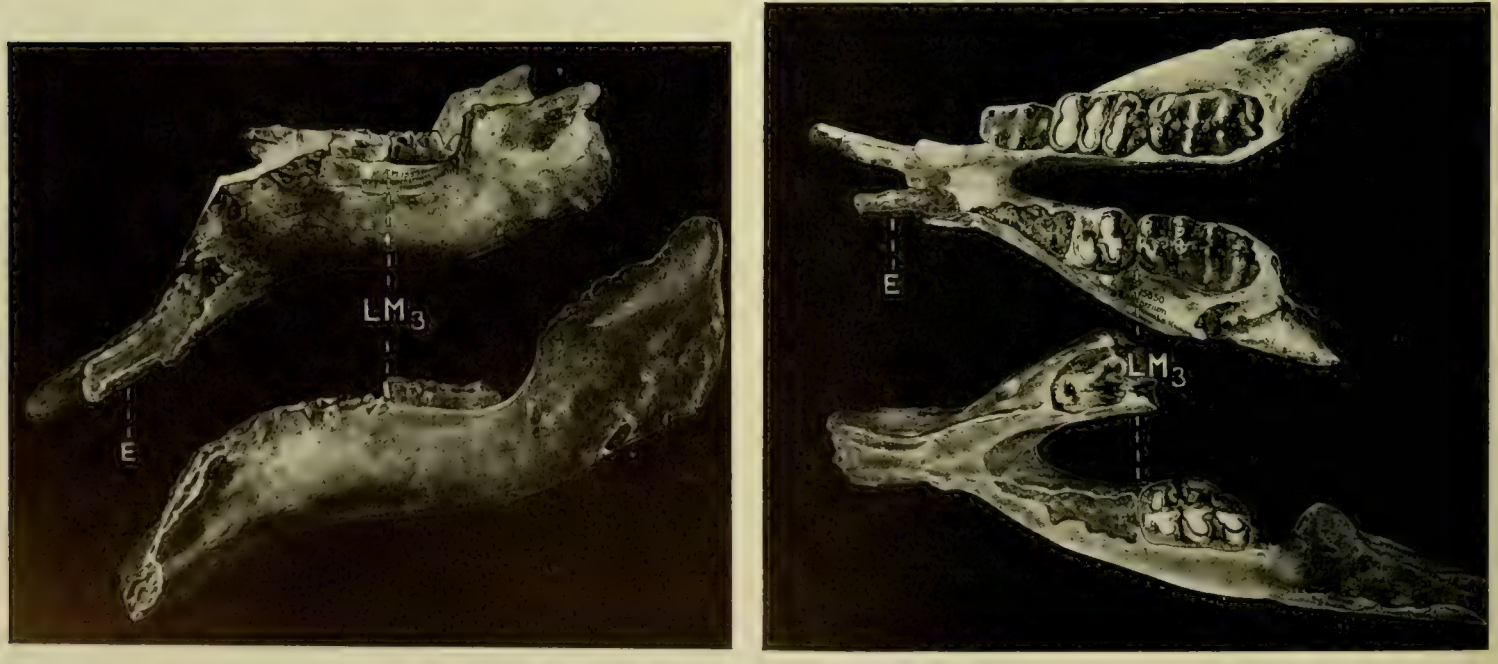
Fig. 446. Type figure of *Stegomastodon nebrascensis* Osborn, 1924.634, p. 4, fig. 2B. One-fourth natural size.

ASSOCIATED FAUNA.—The fauna associated with *Serridentinus nebrascensis*, as found in the Snake Creek B horizon (upper) of western Nebraska, contains *Rhynchotherium anguirivale*, *Serridentinus anguirivalis*, also *Pliomastodon matthewi*, all represented to a one-third scale in figure 394.



RHYNCHOTHERIUM TLASCALÆ, MALE AND FEMALE, FROM THE VALLEY OF MEXICO
RESTORATION BY MARGRET FLINSCH, 1933, UNDER THE DIRECTION OF HENRY FAIRFIELD OSBORN, ONE-FIFTIETH NATURAL SIZE

Fig. 447. This restoration is based on the newly discovered genotypic jaw of *Rhynchotherium* in the Museum of Geneva, observed by Falconer as exhibiting an enormous *bec*, i.e., beak. The characters of the dentition are derived from other species. The cranium is still known only from an anterior fragment of a skull with tusk (*Blickotherium euhypodon*) and an immature maxilla with dentition (*Rhynchotherium shepardi edense*). The characteristic side enamel band of the lower incisors is indicated. A female, with small superior tusks, is in the act of uprooting a plant. While the scene is mountainous, it is probable that these animals were chiefly forest living, an hypothesis in accordance with the extreme rarity of their remains. As shown in the comparative figure 477, *Rhynchotherium tlascalæ* is the largest known Rhynchorostrine, with the largest and most primitive jaw.



(LOWER LEFT-RIGHT) FALCONER'S GENOTYPE CAST OF THE GENUS RHYNCHOTHERIUM, 1856, 1868 (TYPE RHYNCHOTHERIUM TLASCALÆ OSBORN, 1918, 1921), AND (UPPER LEFT-RIGHT) OSBORN'S NEW SPECIES RHYNCHOTHERIUM BROWNI
After retouched photographs, one-tenth natural size. Compare figures 452, 478, and 482

Fig. 448. Lateral (lower left) and crown (lower right) views of Falconer's "lost genotype" from Tlascala, Valley of Mexico; this cast (Amer. Mus. 27003) is a duplicate of "a magnificent specimen of an adult lower jaw of *Mastodon Andium*, invested with a very massive and elongated incisive beak, deflected downwards, and retaining the basal section of one very large incisor [Falc., 1863]." This duplicate of the original cast was prepared and donated (April 20, 1932) to the American Museum by Director Pierre Revilliod of the Geneva Museum.

(Upper left-right) Osborn's erroneous neotype mandible of *Rhynchotherium tlascalæ* Osborn, 1921 (Amer. Mus. 15550), from San José de Pimas, Sonora, Mexico, with its shorter rostrum, is more progressive. It represents a distinct specific stage, to which the name *Rhynchotherium browni* is applied in honor of Barnum Brown's explorations in Mexico.

CHAPTER XI

HISTORY OF THE RHYNCHOROSTRINES, SUBFAMILY RHYNCHOROSTRINÆ ORIGIN AND GEOGRAPHIC DISTRIBUTION OF THE BEAK-JAWED MASTODONTS

SEPARATION OF RHYNCHOTHERIUM FROM TRILOPHODON AND SERRIDENTINUS. RETENTION OF LATERALLY COMPRESSED INFERIOR INCISIVE TUSKS WITH UNIQUE PERSISTENT ENAMEL BAND. POSSIBLE ORIGIN IN 'MASTODON' SPENCERI OF NORTH AFRICA, LOWER MIDDLE MIOCENE, OR IN THE MIO-PLIOCENE RHYNCHOTHERIUM OF INDIA. REAPPEARANCE IN CALIFORNIA, MONTANA, NEBRASKA, COLORADO, TEXAS, THE VALLEY OF MEXICO, AND HONDURAS.

1. Distinction of *Rhynchotherium* from other bunomastodonts.
2. Characters of the subfamily Rhynchorostrinæ and history of discovery.
3. Characters of the genus *Rhynchotherium* and synopsis of the eleven included species thus far discovered.
4. Supposed geologic order of succession of the Rhynchorostrinæ, terminating in Texas, California, Mexico, and Honduras.
5. Synopsis of specific characters of the Miocene species: *Rhynchotherium spenceri, R. brevidens, R. shepardi,* and *R. rectidens.*
6. Synopsis of specific characters of the Pliocene species: *Blickotherium cuhypodon, Rhynchotherium anguirivale, R. tlascalæ, R. browni, R. falconeri, R. shepardi edense,* and *R. francisi.*
7. Mio-Pliocene *Rhynchotherium* of India.
8. New Honduras phylum: *Blickotherium* and *Aybelodon,* discovered by Blick in 1929, described by Frick in 1933.
9. Summary of the evolution of the Rhynchorostrines.

1. DISTINCTION OF RHYNCHOTHERIUM FROM OTHER BUNOMASTODONTS

(May, 1933) The earlier portions of this chapter, completed in 1929 and summarized (pp. 511 513) below, are in part amplified and superseded: (1) By the surprising recent discoveries of Frick, (2) by the recovery of the Geneva genotype cast, and (3) by Osborn's new observations as to habits and phylogeny.

(November, 1934) In the Appendix at the close of the present Volume I the triphyletic sequence of species is set forth.

We owe to the keen vision of that great palæontologist Hugh Falconer the first recognition of this phylum, not in an original specimen, but in a cast[1] of a lower jaw from Mexico contained in 1856 in the Museum of Genoa [now determined as Geneva]. In his own language: "At Genoa I saw a cast of a large lower jaw of a Mastodon from Mexico, with an enormous *bec* abruptly deflected downwards and containing one very large lower incisor. . . . The Genoese palæontologists had provisionally named it *Rhynchotherium*, from the enormous development of the beak, approaching Dinotherium."

In the above paragraph the word 'Genoa' was substituted for the word Geneva, because in Falconer's article of 1863, pp. 55, 56, occurs the following passage:

> The only other dental remains of this species [*Elephas* (= *Parelephas*) *columbi*] which I have seen were some mutilated specimens of adult molars in the Musée Académique of Geneva. They were brought from Mexico, by M. H. de Saussure. No account of them, so far as I am aware, has as yet been brought out; and the notes which I took were of a general character, without entering on details. . . . The same collection contained the cast of a magnificent specimen of an adult lower jaw of *Mastodon Andium*, invested with a very massive and elongated incisive beak, deflected downwards, and retaining the basal section of one very large incisor. The original was stated to have been found near Tlascala, and it appears to be the adult mandibule of the same form, which yielded the younger specimen figured and described by Laurillard in d'Orbigny's Voyage.

The same Tlascala specimen, erroneously referred to '*Mastodon andium*,' is mentioned by Felix and Lenk in 1891, p 133, in the following footnote referring to Falconer, 1868: "Palæont. Mem., Vol. II, p 74. Statt 'Geneva' (Genf) ist hier wohl aus Versehen 'Genoa' (Genua) gedruckt."

[1] Dr. Hans Georg Stehlin (letter, August 1, 1931) kindly located this cast (Fig. 448, lower) in the Muséum d'Histoire Naturelle of Geneva.

The subfamily Rhynchorostrinæ is the least known of all the bunomastodonts; only a few incomplete specimens are found in the museums of the United States and Mexico. From Africa comes the single type jaw of *Rhynchotherium spenceri*. Not a single dental or cranial fragment has thus far been recognized from the entire land mass of Europe and Asia, unless a lower jaw (Amer. Mus. 19415) from the Lower Siwaliks of India proves to be a true *Rhynchotherium;* it has been provisionally named *Rhynchotherium chinjiense*. Only recently have the highly distinctive characters of this subfamily been pointed out by the present author. The natural inference from this rarity of fossil remains is that throughout its entire history *Rhynchotherium* had a habitat quite different from that of *Serridentinus*, of *Trilophodon*, or of *Tetralophodon*—perhaps exclusively water loving and fluviatile, or, on the other hand, mountain loving and sequestered in high forest recesses as in the case of the existing mountain-loving tapir. The isolation of *Rhynchotherium* in its mountain-loving range is well illustrated in the accompanying map (Fig. 451).

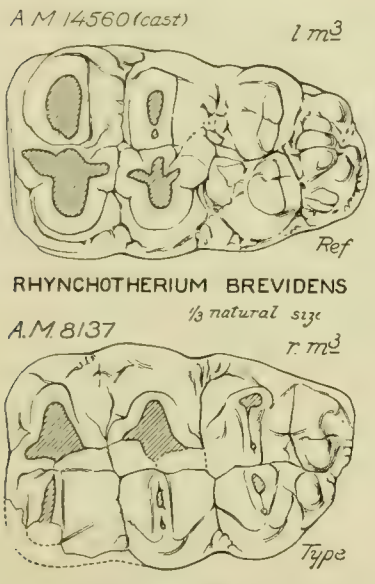


Fig. 449. Type and referred third superior grinding teeth of *Rhynchotherium brevidens* Cope.

(Lower) Type (Amer. Mus. 8137), a third right superior molar, r.M^3.

(Upper) Referred (cast Amer. Mus. 14560), a third left superior molar, l.M^3.

Observe the extreme abbreviation of these grinding teeth, the not fully formed tetartoloph, the extreme thickness of the enamel, the median trefoil spurs, and the resemblance to *Rhynchotherium anguirivale* of the Snake Creek (Figs. 394, 465—Amer. Mus. 19248f,c, 21454). Observe two conelets only on each ridge-crest, also single internal trefoils.

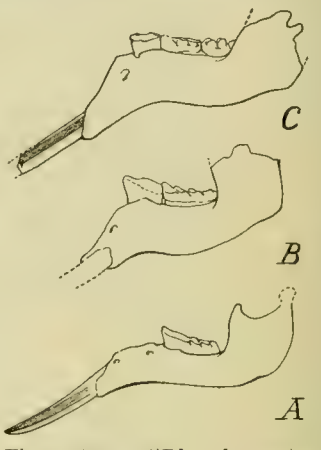


Fig. 450. "Rhynchorostrine types of lower jaw.

A.—*Rhynchotherium* [*Blickotherium*] *euhypodon* Cope. B.—*R. shepardi* Leidy. C.—*R. tlascalæ*, new species [now made the type of *R. browni*]. All figures ¼ natural size."

After Osborn, 1921.515, fig. 2.

Rhynchotherium falls within the family Bunomastodontidæ, because the valleys of the inferior grinders (cf. Fig. 452) are blocked in some species by 'central conules' forming on prolonged wear 'trefoil spurs' (Fig. 452 A2); therefore it is often difficult to distinguish a rhynchorostrine grinder, e.g., M 2 (cf. Fig. 455), from a trilophodont grinder; M 3 (superior or inferior) is, however, more readily distinguished by its abbreviated proportions (cf. Fig. 449, *Rhynchotherium brevidens*). Where the entire lower jaw is preserved (cf. Fig. 453) it is at once distinguishable by the *sharp deflection* of the rostrum, observed even in the primitive *R. spenceri* type (cf. Fig. 453A, Fig. 455), and beneath this deflected rostrum (to which the generic name *Rhynchotherium* or 'beak jawed' refers) the border is actually concave instead of convex as in *Trilophodon* and *Serridentinus*.

The beaklike abbreviation of the rostrum is less extreme in certain species, e.g., *Rhynchotherium spenceri* and *R.* [*Blickotherium*] *euhypodon*(?), than it is in other species, e.g., *R. tlascalæ* and *R. falconeri*. Doubtless progressive abbreviation is a characteristic generic feature. In the more primitive species the rostrum is more elongate, as in *Serridentinus;* in the more progressive species it is more abbreviate.

Another progressive character is the loss of the second molars, M^2-M_2, in the fully adult stage, e.g., *R.* [*Blickotherium*] *euhypodon* (Fig. 462), in which the entire grinding function rests with M^3-M_3.

The retention of fully functional *lower* as well as *upper* incisive tusks doubtless relieved the grinding teeth of extreme complication; accordingly double trefoils are absent, only single evolve. The lophs remain extremely bunodont with no signs of progressive hypsodonty. The superior molars remain broad, abbreviated, and four crested, e.g., *Rhynchotherium brevidens* (Figs. 449, 458); the inferior molars very slowly acquire a fourth crest or tetartolophid (cf. Fig. 452, *R. browni*), and finally show the beginnings of a fifth crest, e.g., *Rhynchotherium* [*Blickotherium*] *euhypodon* and *R. tlascalæ*. With the above brief introduction the history of this subfamily may now be told in detail.

2. CHARACTERS OF THE SUBFAMILY RHYNCHOROSTRINÆ AND HISTORY OF DISCOVERY

SUPERFAMILY: MASTODONTOIDEA Osborn, 1921
FAMILY: BUNOMASTODONTIDÆ Osborn, 1921

SUBFAMILY: RHYNCHOROSTRINÆ Osborn, 1918, 1921

Original reference: Bull. Geol. Soc. Amer., 1918, Vol. XXIX, p. 136 (Osborn, 1918.468); Amer. Mus. Novitates, No. 1, Jan. 31, 1921, p. 5 (Osborn, 1921.515).

SUBFAMILY CHARACTERS.—(1) Face of medium length, maxilla partly downturned. (2) Lower jaw of medium length, symphyseal portion strongly downturned. (3) Superior and inferior tusks persistently functional, laterally compressed, bending downwards and outwards, each with broad external enamel band; inferior tusks slightly upcurved. (4) Grinding teeth persistently simple, brachyodont, inferior 'central conules' variable, single trefoils only, relatively few ridge-crests not exceeding four plus superior, five inferior. (5) Functional grinders in adults finally reduced to one pair above and below, as in *Stegomastodon mirificus*. (6) Molar enamel thick.

The subfamily Rhynchorostrinæ includes the fewest and the least known species, but in many respects it is one of the most interesting phyla of the Bunomastodontidæ. The genus *Rhynchotherium* was first recognized by Falconer (1856 MS., 1868, Vol. II, pp. 74, 75). The subfamily Rhynchorostrinæ was first recognized by Osborn (1918.468) as including not only the *Rhynchotherium* type of Mexico, but a number of rare species in the United States and Mexico, and now even in Egypt and possibly India, which had previously been identified as belonging to *Mastodon*, to *Trilophodon*, to *Tetrabelodon* (i.e., *Tetralophodon*), and to *Dibelodon* (i.e., *Cordillerion*).

HISTORY OF THE GENUS.—The history and clarification of this very confused subject may be cited from Osborn (1918.468, pp. 135 and 136):

Rhynchotherium from Mexico.—Extract of letter from Doctor Falconer to M. Lartet, September 12, 1856. . . . 'At Genoa I saw a cast of a large lower jaw of a mastodon from Mexico, with an enormous *bec* abruptly deflected downwards and containing one very large lower incisor. The beak is much thicker than in *M.* (*Trilophodon*) *angustidens* and larger than in *M.* (*Tetralophodon*) *longirostris*. You know that every one (Laurillard, Gervais, etc.), has insisted on the absence of the lower incisors from both of the South American species. The outline of the jaw resembles very much the figure in Alcide D'Orbigny's Voyage, described by Laurillard as *M. Andium*. The specimen is unpublished material and I was therefore only allowed to examine it very cursorily. The Genoese palæontologists had provisionally [i.e., in MS. labels] named it *Rhynchotherium*, from the enormous development of the beak, approaching Dinotherium.'

As noted above, it appears that Falconer saw this specimen in Geneva and not in Genoa, as part of the collection from Tlascala, Mexico. Attention is called to this by Felix and Lenk (1891). The cast of the jaw in the Museum of Geneva has been reproduced by Director Pierre Revilliod for the American Museum (see Fig. 448, lower).

(Osborn, 1918, p. 135): As shown also in the accompanying scheme, the bunomastodonts, which sprang from *Palæomastodon* [*Phiomia*] of the Oligocene of northern Africa and possibly as well from *Hemimastodon*[1] of southern Asia, divide into three great, long-lived phyla, which may be distinguished as follows:

Longirostral, long-jawed, typified by the species *M. angustidens*.

Medirostral, beak-jawed, typified by *Rhynchotherium*.

Brevirostral, short-jawed, typified by the species *M. mirificus*.

The long-jawed and short-jawed phyla of bunomastodonts are comparatively well known in Europe, Asia, North and South America. The beak-jawed phylum, typified by the genus and species *Rhynchotherium tlaxcalæ*, . . . is provisionally arranged, because there is some uncertainty as to the position of the species *R. cuhypodon* Cope, *R.* (?) *sheperdi* Leidy, and *R. brevidens* Cope. The rhynchotherines are readily distinguished by jaws of medium length, which tend to turn downward into a long, depressed beak, somewhat like that of *Dinotherium*, in which the lower canines [i.e., incisors] are laterally compressed, whereas in all the longirostral bunomastodonts the lower canines [incisors] are vertically compressed.

(Osborn, *op. cit.*, p. 136): There are also some reasons for separating the bunomastodonts into three phyla, which might be known as the *Longirostrinæ*, *Rhynchorostrinæ*, and *Brevirostrinæ*, but this may be a somewhat premature opinion.

[1]Error. The genus *Hemimastodon* Pilgrim is a member of the SUINA.

The above paragraphs with up-to-the-present-date corrections indicated in [ ] include Osborn's 1918 review of the genus *Rhynchotherium* Falconer and the first mention of the subfamily Rhynchorostrinæ Osborn. The following is Osborn's second treatment of the genus *Rhynchotherium* with more precise characters of the subfamily Rhynchorostrinæ (Osborn, 1921.515, pp. 5 and 6):

> The Rhynchorostrinæ. The type of this subfamily (*Rhynchotherium* Falconer, 1868) is a cast (observed in the Genoa [Geneva] Museum by Falconer) of a lower jaw from the Valley of Mexico; the jaw at the time had no specific or generic name. The original genotype may be termed *Rhynchotherium tlascalæ*, new species, from the locality Tlascala. A similar specimen[1] [Amer. Mus. 15550] from Mexico is in the American Museum (Fig. 2 *C* [=Fig. 450 of present Memoir]). The present known range of these animals is Mexico (*R. tlascalæ*), California (*R. shepardi* Leidy), Colorado [Montana] (*R. brevidens* Cope), and Kansas [Nebraska] (*R. euhypodon*[2] Cope). It is noteworthy that the Rhynchorostrines are geologically the earliest forms of proboscideans known in America, i.e., *R. brevidens*, *R. proavus* [=*Serridentinus proavus* in the present Memoir]. The presence of a species of this subfamily in Middle Miocene beds was recently confirmed by Loomis.
>
> The most distinctive feature of this phylum is the downturning of the symphysis, hence the name *Rhynchotherium*, or beak jawed. A second distinction is the retention of the enamel bands on the lower tusks, to which the specific name *euhypodon* Cope (i. e., perfect lower teeth) refers. A third distinctive character is the relative simplicity and small size of the third grinders, hence the specific name *brevidens* Cope, applied to the most ancient form discovered in America. It would appear that the retention of effective upper and lower tusks relieved the grinding teeth in which the evolution is relatively slow. The known geologic succession of species is:
>
> *Rhynchotherium tlascalæ*, new species,[1] 1921. Valley of Mexico [Sonora].
>
> *Rhynchotherium dinotherioides* Andrews, 1909. N. W. Kansas. Pliocene. [=*Trilophodon dinotherioides* in the present Memoir.]
>
> *Rhynchotherium euhypodon*[2] Cope, 1884. Lower Pliocene of Kansas [Nebraska].
>
> *Rhynchotherium shepardi* Leidy, 1871. Stanislaus County, California. ?Miocene.
>
> *Rhynchotherium brevidens* Cope, 1889. Middle [to Upper] Miocene, Deep River, Oregon [Montana].
>
> *?Rhynchotherium proavus* Cope, 1873. Middle [Upper] Miocene, Pawnee Creek, Colorado. [=*Serridentinus proavus* in the present Memoir.]
>
> The maxilla is partly downturned, as well as the mandibular symphysis. Both the superior and inferior incisors are laterally compressed, bending downward and outward. The grinding teeth remain relatively simple, brachyodont, with posterior grinders not exceeding four and a half crests. The intermediate grinders are trilophodont. The grinding series is reduced to $\frac{2}{2}, \frac{1}{1}$ as in *M. mirificus*.

The species *'Mastodon' dinotherioides* Andrews was subsequently observed to belong to the phylum *Trilophodon*, because of the length of the jaw and the complication of the posterior grinding teeth; it is fully described above in Chapter VIII, page 291.

Subfamily Characters.—It is interesting to observe how the three chief subfamily characters, as defined above, have been observed and noted one by one in the generic and successive specific names which have been applied to various members of this phylum: (1) *Rhynchotherium* implies the character 'beak jawed,' hence these animals may be known as the 'beak-jawed mastodonts'; (2) the specific term *Mastodon brevidens*, applied by Cope to the Middle to Upper Miocene species *Rhynchotherium brevidens*, refers to the important subfamily characteristic of short and broad grinding teeth in contrast to the narrow grinding teeth distinctive of the species *Trilophodon angustidens;* (3) when Cope discovered lower tusks bearing enamel, he applied the specific name *Mastodon euhypodon*, signifying 'perfect lower teeth,' to the Lower Pliocene species *Rhynchotherium euhypodon*[2]; (4) of the other specific names, *Mastodon shepardi* was assigned in honor of the owner of the material, Prof. C. N. Shepard, while the specific name *R. anguirivale* is purely geographic.

Third Definition of the Subfamily, Osborn, 1927.—In the successive observations of Falconer (1856, 1868) and of Osborn (1918.468, 1921.515), four specific stages were grouped within the genus constituting this phylum, namely:

[1]Made the type of *Rhynchotherium browni* in the present Memoir (see p. 494).
[2]Referred in the present Memoir to Frick's new genus *Blickotherium*.

Rhynchotherium tlascalæ Osborn, 1918, Valley of Mexico. Type. Upper (?) Pliocene.
Rhynchotherium tlascalæ Osborn, 1921, Sonora, Mexico. Neotype.[1] Upper (?) Pliocene.
Mastodon shepardi Leidy, 1871, central California, Stanislaus County. Upper (?) Miocene.
Mastodon euhypodon[2] Cope, 1884, Republican River beds, Driftwood Creek, Hitchcock County, Nebraska. Lower Pliocene.
Tetrabelodon brevidens Cope, 1889, Deep River beds, Smith River, Meagher County, Montana. Middle to Upper Miocene.

Having by comparison established the common characters and the evolutionary tendencies displayed in these four species, there remain, first, a number of other specific stages to be recognized or discovered, and second, the tracing of this phylum back into its Eurasiatic or Old World ancestry.

AFRICAN(?) ORIGIN.—The last object was somewhat doubtfully accomplished through the recognition of the *Mastodon spenceri* of Fourtau, 1918, from Moghara, Egypt, as a primitive North African member of this phylum: this hypothesis naturally requires confirmation by further examination of the original type of *M. spenceri*. Supplementing this doubtfully placed species are several new specific stages clearly defined in the United States and Mexico together with the possible occurrence in India of the provisionally named species *Rhynchotherium chinjiense*. The history of discovery may now be summarized as follows:

SPECIES OF RHYNCHOROSTRINÆ IN THEIR ORDER OF DISCOVERY AND DESCRIPTION

See figure 451

		ORIGINAL NAME	SPECIFIC REFERENCE IN PRESENT MEMOIR
	1856–1868	*Rhynchotherium* recognized as a new genus by Falconer	= *Rhynchotherium*
1.	1871	*Mastodon shepardi* Leidy, Dry Creek, Stanislaus County, California	= *Rhynchotherium shepardi*
2.	1884	*Mastodon euhypodon* Cope, Trail Cañon, Driftwood Creek, Hitchcock County, Nebraska	= *Blickotherium euhypodon*
3.	1889	*Tetrabelodon brevidens* Cope, Smith River, Meagher County, Montana	= *Rhynchotherium brevidens*
4.	1918	*Rhynchotherium tlascalæ* Osborn, from near (?)Tlascala, Valley of Mexico (Falconer's Genoa [Geneva] cast, made by Osborn the TYPE of *Rhynchotherium*)	= *Rhynchotherium tlascalæ*
5.	1918	*Mastodon spenceri* Fourtau, Moghara, Egypt	= *Rhynchotherium(?) spenceri*
6.	1921	*Trilophodon (Tetrabelodon) shepardi edensis* Frick, Mt. Eden Hot Springs, San Bernardino County, California	= *Rhynchotherium shepardi edense*
6.	1922	*Dibelodon edensis* (Frick) Osborn, Mt. Eden Hot Springs, San Bernardino County, California	= *Rhynchotherium shepardi edense*
7.	1923	*Rhynchotherium rectidens* Osborn, Pawnee Buttes, Colorado	= *Rhynchotherium rectidens*
8.	1923	*Rhynchotherium falconeri* Osborn, Blanco formation, Llano Estacado, Texas	= *Rhynchotherium falconeri*
9.	1926	*Rhynchotherium anguirivalis* Osborn, Snake Creek B, Sioux County, western Nebraska	= *Rhynchotherium anguirivalis*
10.	1926	*Mammut francisi* Hay, Pittbridge, Burleson County, Texas	= *Rhynchotherium francisi*
6.	1926	?*Rhynchotherium (Dibelodon) edensis* Frick, Mt. Eden Hot Springs, San Bernardino County, California	= *Rhynchotherium shepardi edense*
6.	1927	*Rhynchotherium paredensis* Osborn, Mt. Eden Hot Springs, San Bernardino County, California	= *Rhynchotherium shepardi edense*
11.	1929	*Rhynchotherium chinjiensis* Osborn, near Chinji Bungalow, Lower Siwaliks, India	= *Rhynchotherium chinjiense*
	1930	*Rhynchotherium serpentirivale* Hay, Snake Creek, Sioux County, Nebraska	= *Nomen nudum*
12.	1933	*Blickotherium blicki* Frick, near Tapasuma, Gracios, Honduras	= *Blickotherium blicki*
13.	1933	*Aybelodon hondurensis* Frick, near Tapasuma, Gracios, Honduras	= *Aybelodon hondurensis*
14.	1921–1935	*Rhynchotherium tlascalæ* Osborn, NEOTYPE, San José de Pimas, Sonora, Mexico	= *Rhynchotherium brevensi* sp. nov.

Examination of the characters and of the geographic distribution of the above fourteen species enables us to give a clear synopsis of the characters of *Rhynchotherium* and of the distribution of the subfamily Rhynchorostrinæ.

[1]See footnote 1 on page 478.
[2]See footnote 2 on page 478.

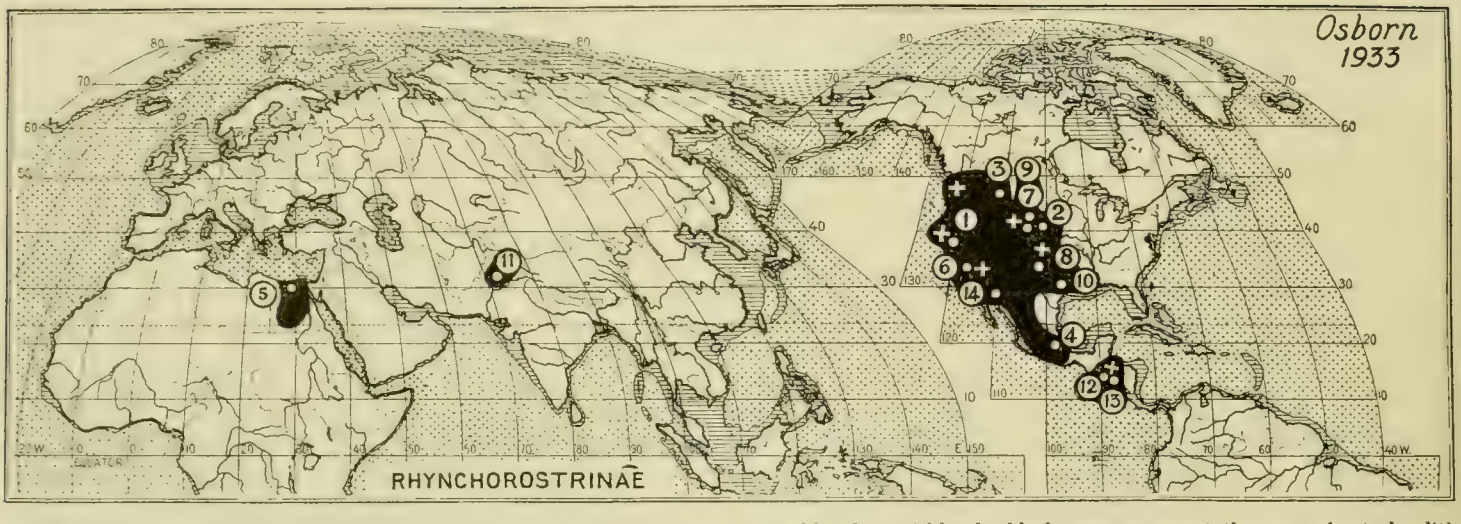


Fig. 451. Geographic distribution of species of the Rhynchorostrinæ. The white dots within the black areas represent the approximate localities where the types of these fourteen species were discovered. Geographic range (?) Egypt, (?) India, Montana to Texas, Mexico, and Honduras. The white crosses represent referred specimens mentioned in the present Memoir.

1. *Rhynchotherium shepardi*, California
2. *Blickotherium euhypodon*, Nebraska
3. *Rhynchotherium brevidens*, Montana
4. *Rhynchotherium tlascalæ*, Mexico
5. *Rhynchotherium spenceri*, Egypt
6. *Rhynchotherium shepardi edense*, California
7. *Rhynchotherium rectidens*, Colorado
8. *Rhynchotherium falconeri*, Texas
9. *Rhynchotherium anguirivale*, Nebraska
10. *Rhynchotherium francisi*, Texas
11. *Rhynchotherium chinjiense*, India
12. *Blickotherium blicki*, Honduras
13. *Aybelodon hondurensis*, Honduras
14. *Rhynchotherium browni*, Mexico

3. CHARACTERS OF THE GENUS RHYNCHOTHERIUM AND SYNOPSIS OF THE ELEVEN INCLUDED SPECIES THUS FAR DISCOVERED

Genus: **RHYNCHOTHERIUM** Falconer, 1856 (MS.), 1863, 1868

Original reference: Falconer (in Murchison), Palæontological Memoirs, 1868, Vol. II, pp. 74, 75.

Genotypic Species: *Rhynchotherium tlascalæ* Osborn, 1918.468.

Syn.: *Dibelodon* Cope, 1884, genotypic species *Mastodon shepardi* Leidy. By an unexpected application of the law of priority, Cope's genus *Dibelodon*, 1884, founded on the genotypic species '*Mastodon*' *shepardi* Leidy, becomes a synonym of *Rhynchotherium* Falconer, 1856-1868. Thus the generic name *Dibelodon*, very widely used in connection with the Andean mastodonts, becomes a *nomen nudum*.

Known Geographic Range: (?) North Africa (Egypt), (?)India, western and southern United States of America (California, Nebraska, Montana, Colorado, Texas), Mexico, and Honduras.

Known Geologic Range: Miocene of (?) Egypt, Mio-Pliocene of India, Middle to Upper Miocene of Montana, Upper Miocene-Upper Pliocene of California, Nebraska, Texas, Colorado, Mexico, and Honduras.

Generic Characters. —There are eleven species which, with the possible exception of *Mastodon spenceri* of the Middle Miocene, Moghara, northern Egypt, are certainly to be referred to this genus and which together enable us to establish on a sure foundation the generic distinctions of *Rhynchotherium* as follows: (1) Grinding teeth of bunomastodont type, relatively broad, simple, brachyodont; (2) intermediate grinders with three crests (like *Trilophodon*); (3) third superior grinders with three and a half to four plus crests, third inferior grinders not exceeding four and a half to five crests (*R. anguirivale*); (4) functional grinders in adults reduced to M 2–M 3, finally to M 3 (as in *Stegomastodon mirificus* and in progressive *Trilophodon*, but unlike *Serridentinus*); (5) superior and inferior incisors, I^2-I_2, laterally compressed, with broad external enamel band, bent downwards and outwards; (6) face of medium length, maxilla partly downturned; (7) symphysis of lower jaw sharply downturned bearing two inferior tusks, each with broad enamel band (unlike *Trilophodon* and *Serridentinus*); (8) single trefoils only; (9) inferior 'central conules' variable (Fig. 452), superior 'central conules' absent (Fig. 473).

As remarked above, we owe the recognition of this genus to the keen vision of Hugh Falconer in observing the cast in the Museum of Geneva (Fig. 448, lower). His original letter to Lartet, September 12, 1856 (Falconer, 1868, Vol. II, pp. 74, 75) may be cited again (compare also Osborn, 1918.468, p. 136):

'At Genoa I saw a cast of a large lower jaw of a Mastodon from Mexico, with an enormous *bec* abruptly deflected downwards and containing one very large lower incisor. The beak is much thicker than in *M.* (*Tetralophodon*) *angustidens* and larger than in *M.* (*Tetralophodon*) *longirostris*. You know that every one (Laurillard, Gervais, &c) has insisted on the absence

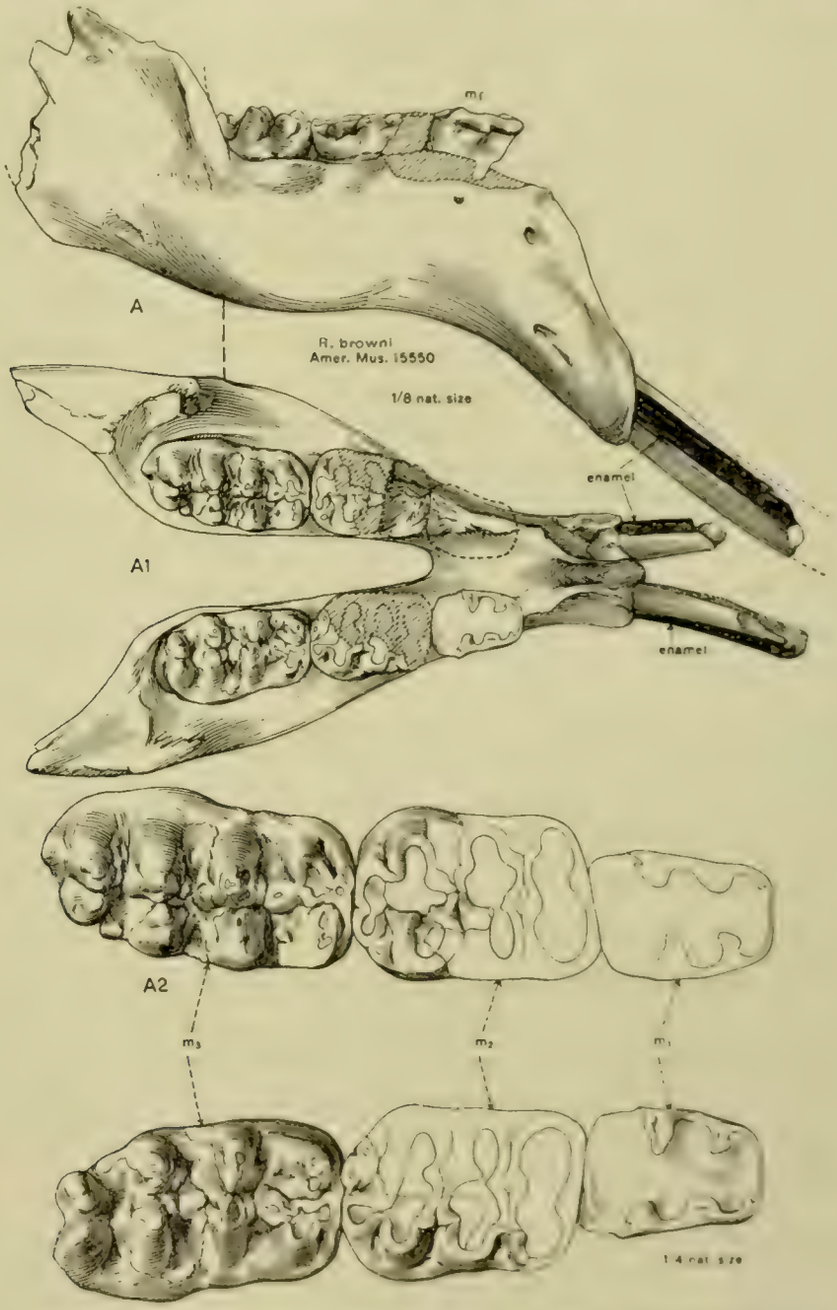


Fig. 452. Type of *Rhynchotherium browni* sp. nov., formerly (1921) Osborn's neotype of *R. tlascalæ* (Amer. Mus. 15550), from near San José de Pimas, Sonora, Mexico. Observe lateral enamel band on slightly upcurved inferior tusks; also ridge formula, namely, M 1_3, M $2\frac{3}{3}$ M $3\frac{4}{3}$. Trefoils on outer side only; crowns relatively broad, elongate. Observe two posterior conelets on M_2 (=tetartolophid). Observe 'central conules.'

A, Right lateral aspect; A1, superior aspect. Both one-eighth natural size.

A2, Grinding teeth enlarged to one-fourth natural size.

of the lower incisors from both of the South American species. The outline of the jaw resembles very much the figure in Alcide D'Orbigny's Voyage, described by Laurillard as *M. Andium*. The specimen is unpublished material, and I was therefore only allowed to examine it very cursorily. The Genoese palæontologists had provisionally [i.e., in MS. labels] named it *Rhynchotherium*, from the enormous development of the beak, approaching Dinotherium.'

The presence of *Rhynchotherium* in Mexico is abundantly confirmed by Barnum Brown's discovery in 1911 of the jaw (Amer. Mus. 15550) which Osborn (1921) made the neotype[1] of the species *Rhynchotherium tlascalæ*, the specific name being of historic interest in connection with the Spanish Conquest. Consequently this specific name, given by Osborn after the historic town of Tlascala in the Valley of Mexico, is as follows (Osborn, 1918.468, p. 135):

The beak-jawed phylum, typified by the genus and species *Rhynchotherium tlaxcalæ*, . . . is provisionally arranged, because there is some uncertainty as to the position of the species *R. euhypodon* Cope, *R.(?) shepardi* Leidy, and *R. brevidens* Cope. The rhynchotherines are readily distinguished by jaws of medium length, which tend to turn downward into a long, depressed beak, somewhat like that of *Dinotherium*, in which the lower canines [i.e., incisors] are laterally compressed, whereas in all the longirostral bunomastodonts the lower canines [incisors] are vertically compressed.

Generic and Specific Distinctions.—(1) The name of this genus implies 'beak jawed,' as expressed by Falconer. (2) Inasmuch as both the superior and inferior tusks are functional and covered on the sides with enamel, by the *law of compensation* the grinding teeth are relatively broad and short with few ridge-crests, as implied in the name *M. brevidens* applied by Cope to this Miocene species. (3) These animals are unique in the retention of an enamel band on the lower tusks as well as on the upper, as implied in the specific name *euhypodon* (i.e., 'perfect lower teeth') applied to the Nebraska type by Cope. (4) It is not surprising that Leidy applied the noncommittal name *M. shepardi* to a fragment of a tusk from California which he described in 1871. We have succeeded in assembling the nearly complete upper tusks of his type specimen, reconstructed in figure 459; certainly these tusks of *M. shepardi*, except for their extreme narrowness, might readily be mistaken for those of a typical Miocene *Trilophodon*.

Through the collection and examination of valuable additional material from the locality of San José de Pimas, Sonora, Mexico (neotype[1] jaw, Amer. Mus. 15550—cf. Fig. 452), we now understand the full dental characters of the lower jaw in the genotypic species *Rhynchotherium tlascalæ* Osborn. A stage leading up to this very progressive species is *R. falconeri* of the Blanco formation, Upper Pliocene, Texas (Fig. 468). Honduras yields the Tambla tooth (Fig. 454C), referred by Leidy, 1869, p. 242, to '*Mastodon andium*.' It is regarded as certainly a member of the Rhynchorostrinæ and allied to *Rhynchotherium browni* of Sonora (cf. Fig. 452).

Pliocene Rhynchotherium in Florida (W. D. Matthew, Pierce, Florida, March 14, 1924).—The Floridian beds near Pierce and Brewster, Polk County, Florida, consist of pebble phosphates due to the working over by the sea of phosphatic beds, and to subsequent concentration of the phosphatic pebbles into a basal conglomerate rich enough to pay working. The geologic age of this pebble-conglomerate is of early or middle Pliocene time. Fossils occur in this conglomerate including mostly marine animals but with some land animals, the remains of most of them having been rolled and broken.

These fossils represent apparently three species of mastodonts—one, a *Pliomastodon*, the other two related to the 'beak-jawed mastodont' and comparable to *Rhynchotherium euhypodon*,[2] with short jaw and heavy downturned lower tusk; the intermediate molars, P 4–M 2 inclusive, are of simple trilophodont structure with the characteristic type of molar cresting.

[1]Osborn's neotype of *Rhynchotherium tlascalæ* is herewith (p. 494) made the type of a new species, *Rhynchotherium browni* (see Figs. 452, 467).

[2](Simpson, 1930, p. 202) "The proboscideans of the Alachua and Bone Valley belong to two groups, the Serridentinæ and the Mastodontinæ. The rather rich collections examined do not contain any trace of *Stegomastodon* or *Rhynchotherium*. Some of the serridentine material suggests the latter genus but more complete specimens prove it to be absent in the known material.

4. SUPPOSED GEOLOGIC ORDER OF SUCCESSION OF THE RHYNCHOROSTRINÆ, TERMINATING IN TEXAS, CALIFORNIA, MEXICO, AND HONDURAS

GEOLOGIC SUCCESSION.—To understand the phylogenetic characters, we may place the twelve[1] species in their descending geologic order, beginning at the top with the most recent stage, *Rhynchotherium falconeri* of Texas, and descending to the theoretically most ancient stage, *R. spenceri* of Egypt.

Upper Pliocene	*Rhynchotherium falconeri* Osborn, 1923, Blanco formation, Texas. Intermediate in size but slightly more progressive in abbreviation of the rostrum (Fig. 468).
Upper Pliocene	*Rhynchotherium browni* sp. nov., Sonora, Mexico. Based upon a lower jaw (Fig. 467).
Upper(?) Pliocene	*Rhynchotherium tlascalæ* Osborn, 1918, Valley of Mexico. Large and progressive species (Fig. 448).
Upper Pliocene	*Rhynchotherium shepardi edense* Frick, Mt. Eden Hot Springs, San Bernardino County, California. Based upon superior maxillaries and grinding teeth (Fig. 470).
Pliocene	*Rhynchotherium francisi* Hay, Brazos River, Pittbridge, Burleson Co., Texas. Based upon a third superior molar of the right side (Fig. 475).
Lower Pliocene	*Rhynchotherium anguirivale* Osborn, 1926, Snake Creek B (upper), Sioux County, western Nebraska. Based upon a third right inferior molar (Figs. 465 and 466).
Lower Pliocene	*Rhynchotherium* [*Blickotherium*] *euhypodon* Cope, 1884, Republican River beds, Nebraska. An aged individual, M^3-M_3 only in use (Fig. 462).
Upper Miocene	*Rhynchotherium rectidens* Osborn, 1923, near Pawnee Buttes, Weld County, Colorado. Based upon a pair of right and left superior tusks, nearly straight in contour (Fig. 461).
Upper(?) Miocene	*Rhynchotherium shepardi* Leidy, 1871, Stanislaus County, central California. Based upon fragments of right and left superior tusks (Fig. 459).
Middle to Upper Miocene	*Rhynchotherium brevidens* Cope, 1889, Smith River, Montana. Based upon a third right superior grinding tooth (Figs. 456 and 457).
Mio-Pliocene	*Rhynchotherium chinjiense* Osborn, 1929. Based upon left ramus with M_2, M_3 *in situ* (Fig. 476).
Middle Miocene	*Rhynchotherium spenceri* Fourtau, 1918, Moghara, Egypt. Based upon a lower jaw with downturned symphysis and laterally compressed incisive alveoli (Fig. 455).

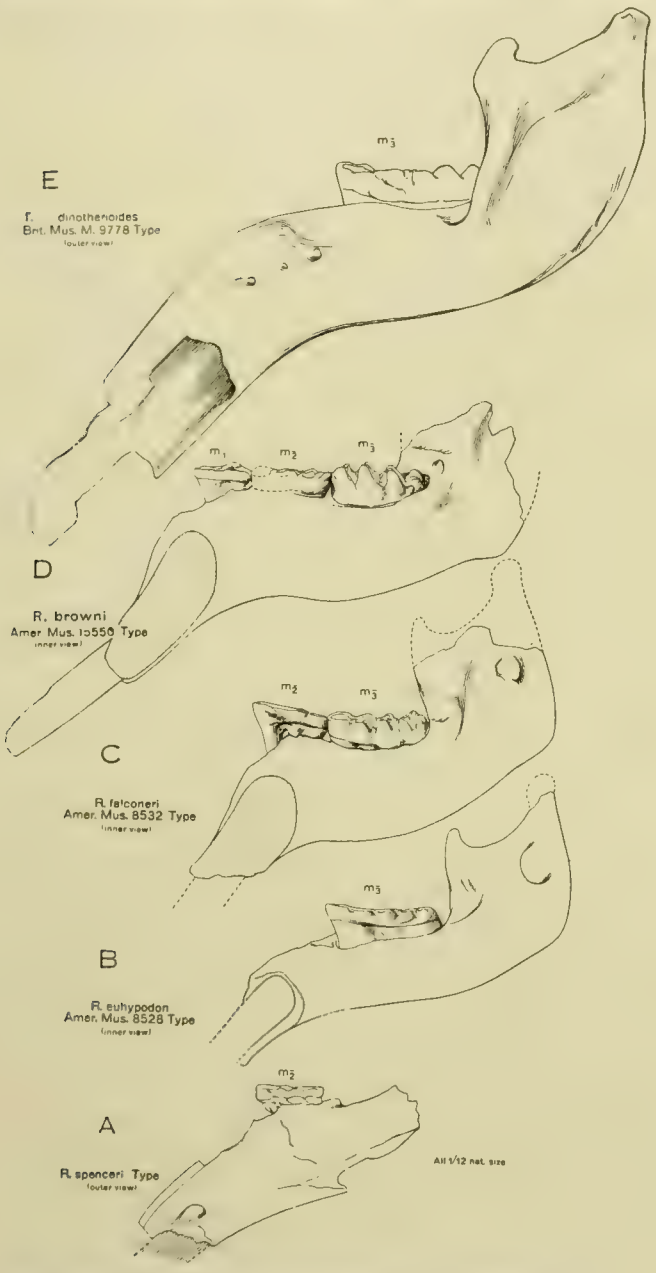
PERSISTENT AND PROGRESSIVE CHARACTERS.—Among the persistent characters in this phylum are: (1) The enamel band on the inferior and superior tusks; (2) the active functional use of the inferior as well as of the superior tusks in peculiar uprooting habits, which were probably quite distinct from those in the long-jawed species of *Trilophodon;* (3) persistent and simple third superior and inferior grinding teeth, brachyodont, with single trefoils. Among the progressive characters are: (1) Progressive increase in size; (2) gradual loss of the functional use of M 1, M 2, thus, in an advanced stage, throwing the entire grinding function on M 3.

COMPARATIVE PROPORTIONS OF RHYNCHOTHERIUM AND SERRIDENTINUS GRINDERS

Molar Series	M_1						M_2						M_3						M^3					
	Right			Left			Right			Left			Right			Left			Right			Left		
M 1–M 3	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.
R. browni	98	67	68	..	..	..	136e	100	74e	..	97	..	176	96	55	180e	96	53e	..	..	..			
R. falconeri	..	..	..	..	..	..	133e	77	58e	131e	79e	60e	173	80	46	168	80	48	..	..	..			
R. anguirivale	..	..	..	..	..	..	..	..	..	..	..	..	214	98	46	..	..	..	..	..	..	163e	83	51e
R. [*B.*] *euhypodon*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	182	78	43	179	96	54	179	103	58
R. shepardi ref.	..	..	..	..	..	..	..	..	..	..	..	..	162.5	72.5	45	..	..							
R. brevidens																								
Amer. Mus. 8137 (type)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	154	98	64	..	..	..
Amer. Mus. 14560 (ref.)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	160	92	57
R. shepardi edense																								
Amer. Mus. 18225 (Frick Coll.) neotype	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	176	80	45	..	..	..	..	..	..
Univ. Calif. 23501 (type)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	150	80	53
S. serridens																								
Amer. Mus. 10673 (ref.)	92	62	67	..	..	..	139	69	50															
S. productus																								
Amer. Mus. 10582 (ref.)	..	..	..	..	..	..	124e	75	60e	..	..	..	163	76	47	..	..	..	142	85	60			

[1]Two additional species, *Blickotherium blicki* Frick and *Aybelodon hondurensis* Frick, from the Pliocene of Honduras, were added in the year 1933, making fourteen in all.

GRINDING TEETH.—The grinding teeth in these two genera are not harmonic with the tusks. It appears that, allowing for the very marked differences in proportion and indices caused by crushing, the grinding teeth in *Rhynchotherium* are substantially similar in proportion to those of *Serridentinus*. The breadth-length indices of the third inferior molar in *R. browni* (=53), in *R. falconeri* (=48), and in *R.* [=*Blickotherium*] *euhypodon* (=43) show that in *R. euhypodon* the third upper and lower molars are unusually narrow, namely, index 43 of M_3.



TYPE JAWS (A-D) OF THE RHYNCHOROSTRINÆ, COMPARED WITH TYPE JAW (E) OF TRILOPHODON DINOTHERIOIDES

One-twelfth natural size

Fig. 453. Observe contrast in M_3: *Rhynchotherium* with 3-4+ ridge-crests; *Trilophodon* with 4-5½ ridge-crests.

E, Type jaw of *Trilophodon dinotherioides* Andrews (Brit. Mus. M. 9778), Kansas. After Andrews, 1909.1, p. 348.

D, *R. browni* sp. nov. (Amer. Mus. 15550), formerly the neotype of *R. tlascalæ* Osborn, 1921. From Sonora, Mexico, American Museum Expedition of 1911, collected by Barnum Brown.

C, Type of *R. falconeri* Osborn, 1923 (Amer. Mus. Cope Coll. 8532), Blanco formation, Texas. A specimen originally referred by Cope to *Tetrabelodon shepardii*.

B, Type of *R.* [*Blickotherium*] *euhypodon* Cope, 1884 (Amer. Mus. Cope Coll. 8528), Trail Cañon, south fork of Driftwood Creek, Hitchcock County, Nebraska.

A, Type of *R. spenceri* Fourtau, 1918. Originally described and figured as *Mastodon spenceri*. From the Moghara Desert, Egypt.

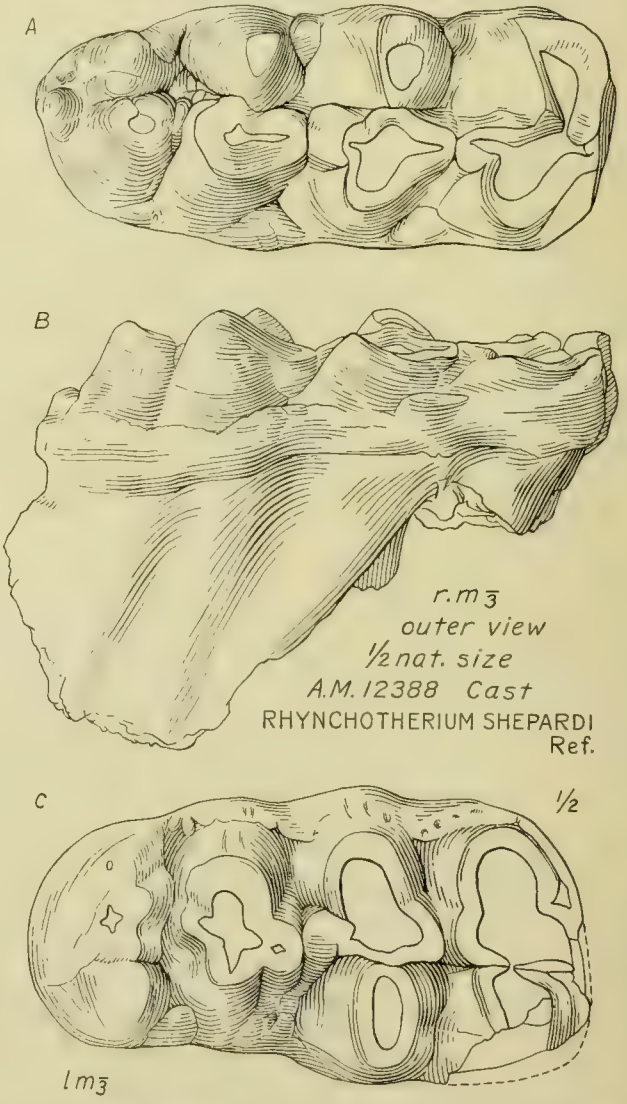


FIG. 454. RHYNCHOTHERIUM FROM CALIFORNIA (A, B) AND TAMBLA, HONDURAS (C), DESCRIBED BY LEIDY

Both one-half natural size

A, B, Last lower molar of the right side, r.M_3 (Amherst Coll.; cast Amer. Mus. 12388), from Contra Costa County, California; described by Leidy, 1873, p. 235, as almost identical with the molar, also from Contra Costa County, figured by him as '*Mastodon' obscurus* on Pl. XXI, figs. 1, 2—figure 469 of the present Memoir. [=*Rhynchotherium shepardi* ref.]

C, "Last superior [inferior] molar of the left side," l.M^3 [l.M_3], in the Museum of the Academy of Natural Sciences, Philadelphia, from Tambla, Honduras; figured and described by Leidy, 1869, Pl. XXVII, fig. 14, and p. 424, as possibly referable to '*Mastodon andium*.' Meas.: ap. 156 mm., tr. 84 mm., index, 54. [=*Rhynchotherium browni* ref.]

5. SYNOPSIS OF SPECIFIC CHARACTERS OF THE MIOCENE SPECIES

Rhynchotherium spenceri Fourtau, 1918

Figures 453, 455, 477, 478, and 482

Middle Miocene, Moghara Desert, northern Egypt.

It will be a matter of extraordinary interest if the *Mastodon spenceri* of Fourtau proves on further examination to be a member of the *Rhynchotherium* phylum, thus carrying the phylum back to an African source. It will be observed in the following complete citation from Fourtau's description that he distinguished this type jaw from that of *M. angustidens* by the downturned symphysis, . . . "ce fragment ne saurait être rattaché au *M. angustidens* dont la symphyse mentonnière n'est nullement déjetée vers le bas." He also speaks of the development of a posterior talon or rudimentary tetartolophid in M_2 as evidence of a tendency to pass into the *T. longirostris* type.

TYPE OF RHYNCHOTHERIUM SPENCERI

Fig. 455. Type of *Mastodon Spenceri* Fourtau, 1918, figs. 60 and 61. From the desert of Moghara, Egypt.

(Fig. 60, lower) Crown view of the type molar, M_2, one-half natural size. (Fig. 61, upper) Lateral aspect of the type jaw, one-fourth natural size. This type is also figured in comparison with the American Rhynchorostrines and reduced to the same scale (Fig. 453), demonstrating that it is not improbably a primitive Rhynchorostrine, which should be known as *Rhynchotherium spenceri*. Observe the very large foramen in anterior portion of jaw opposite symphysis.

Mastodon Spenceri, Fourtau, 1918. "Contribution a l'Étude des Vertébrés Miocènes de l'Égypte." Ministry of Finance, Egypt. Surv. Dept., 1918, pp. 89–91. TYPE.—(*Op. cit.*, p. 89): "Deuxième molaire inférieure de droite vue par la face triturante." (*Op. cit.*, p. 90): "Branche droite de la mandibule." HORIZON AND LOCALITY.—Moghara, northern Egypt, Middle Miocene. TYPE FIGURE.—*Op. cit.*, p. 89, fig. 60, p. 90, fig. 61.

TYPE DESCRIPTION.—(Fourtau, 1918, p. 89): "Le Lieutenant Robert Spencer, du Denbighshire Hussards Yeomanry, a recueilli à la base de l'escarpement de Moghara une mandibule de mastodonte fort incomplète, il est vrai, mais présentant des caractères très particuliers qui me paraissent justifier la création d'une coupure à part dans le groupe des trilophodontes. Ce spécimen est constitué par la branche droite de la mandibule dont la partie postérieure est absente et par la symphyse à peu près complète des deux branches. Comme dentition, nous avons M_2 droite en assez bon état."

(*Op. cit.*, 1918, p. 91): "Rapports et Différences.—Tel qu'il est, ce fragment ne saurait être rattaché au *M. angustidens* dont la symphyse mentonnière n'est nullement déjetée vers le bas. Il ne saurait non plus être rattaché au *M. longirostris* dont la dentition est nettement tétralophodonte, mais on peut y voir, à mon avis, une forme établissant le passage entre ces deux espèces. Le développement du talon postérieur de M_2 est évidemment un passage à la dentition tétralophodonte et le déjet de la symphyse nous amène au type du Miocène supérieur de la vallée du Rhône et d'Eppelsheim, bien que ce déjet soit plus prononcé sur notre animal. Nous devons donc considérer cette pièce comme une forme nouvelle que je dédie à son inventeur le Lieutenant Robert Spencer."

(*Op. cit.*, 1918, p. 91): "OBSERVATIONS GÉNÉRALES SUR LES PROBOSCIDIENS DU GISEMENT DE MOGHARA.—Le gisement de Moghara est certainement le plus riche gisement de mastodontes de l'Afrique du Nord où, jusqu'à présent, on ne connaissait que quelques localités d'Algérie (Smendou et tranchée de la route de Chabet el Ameur à Isserville) et de Tunisie (Kenchela et massif du Cherichira), localités qui n'ont, en somme, fourni que quelques débris. Des fouilles méthodiques à Moghara donneront certainement de nombreuses pièces. Mais il est un fait assez bizarre à constater, c'est l'absence totale de restes de *Dinotherium*, le compagnon habituel des mastodontes miocènes. Il semblerait donc que ces animaux ne sont pas d'origine africaine, et que les restes signalés dans l'Ouganda et en Ethiopie, . . . [Footnote: 'E. Haug. —Traité de Géologie, tome II (2), p. 1727.'] à des horizons bien supérieurs, proviendraient d'une migration postérieure à l'apparition des *Dinotherium* en Asie et en Europe."

Rhynchotherium brevidens Cope, 1889

Figures 449, 456–458

Deep River horizon, Smith River, Meagher County, Montana, Middle to Upper Miocene, "Tiholeptus bed of Cope," correlated in time with the Pawnee Creek of northeastern Colorado and the Mascall of Oregon.

The species *Rhynchotherium brevidens* (1889) is of approximately the same geologic age as the species described above as *Serridentinus proavus* (1873) and below as *Rhynchotherium rectidens* (1923). The type molar of *R. brevidens* is very clearly distinguished by its broad, low crown from the type molar of *S. proavus*.

Tetrabelodon brevidens Cope, 1889. "The Proboscidia." Amer Nat., Vol. XXIII, 1889, pp. 198–202. TYPE.—Third right

superior molar, r.M³. Amer. Mus. Cope Coll. 8137. Horizon and Locality.—Smith River, Meagher County, Montana, Deep River horizon, "Ticholeptus bed of Cope." The Ticholeptus bed of Montana, otherwise known as the Deep River of Montana, is of Middle to Upper Miocene age, correlated in time with the Pawnee Creek beds of Colorado which yielded the type of *Mastodon proavus* Cope. Type Figure.—*Op. cit.*, Cope, 1889.2, p. 201, fig. 5.

Specific Characters (Cope, 1889.2, pp. 201, 202).—(1) The geologically oldest North American species. (2) Very simple type of molar, the last superior molar (type) with but three cross-crests and a heel, a smaller number than exists in any other species of the genus [*Tetrabelodon*]. (3) Tooth wide; crests low. Length 154 mm.; width at second crest, 98 mm.; index 64; elevation of second crest, 54 mm. Lobes divided by longitudinal fissure. (4) Internal lobes bearing trefoils on crests one and two only. Internal border with well-defined cingulum or ledge. (5) Reduced number of crests indicates its primitive character, hence the presence of well-developed lower incisor teeth is suspected. (6) Probably ancestral to *M. americanus*.

Osborn, 1924: The original (Fig. 456) and new (Fig. 457) type figures illustrate very clearly the extreme abbreviation and simplicity of the third right superior molar tooth, r.M³, on which this species is based. The length of this tooth, 154 mm., in comparison with the width, 98 mm., at the second crest gives us a breadth-length index of 64, as compared with a breadth-length index of 51 in *Trilophodon angustidens* and of 60 in *Serridentinus productus*.

Referred Superior Molar from Eastern Washington.—The fortunate discovery by Dr. John P. Buwalda of a third superior molar of the left side, l.M³ (Amer. Mus. 14560) enables us to give the characters and measurements of this referred superior tooth supplementing those clearly shown in the type figures. The length of this superior tooth, 160 mm., in comparison with the maximum width at the anterior crest, 92 mm., gives us a breadth-length index of 57 for M³, as compared with a breadth-length index of 64 for the type M³.

While the reference of this superior molar (Fig. 458) to *Rhynchotherium brevidens* requires confirmation by the discovery of associated upper and lower jaws and teeth, there is nothing in the above measurements, proportions, and indices to preclude the present specific reference.

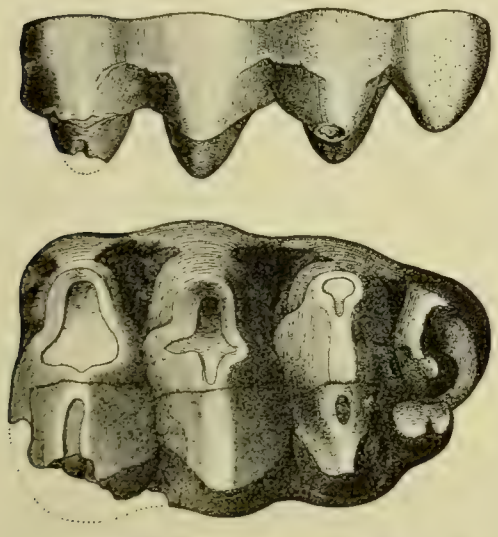
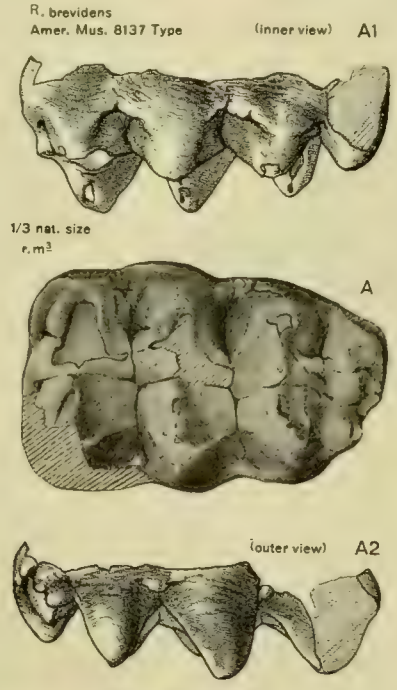


Fig. 5. *Tetrabelodon brevidens* Cope; last superior molar; from Ticholeptus bed of Montana. Four-ninths natural size. Original.



Type Right Third Superior Molar of Rhynchotherium brevidens

Fig. 456. Type figure of *Tetrabelodon brevidens* Cope, 1889. Amer. Mus. Cope Coll. 8137. After original woodcut engraving published by Cope in his paper on "The Proboscidia" (Cope, 1889.2), p. 201, fig. 5, four-ninths natural size.

A third superior molar of the right side, r.M³. Compare with *R. brevidens* ref. (cast Amer. Mus. 14560) shown in figures 449 and 458.

Fig. 457. New figure of type molar of *Tetrabelodon brevidens* Cope, from the Middle to Upper Miocene "Ticholeptus bed of Cope," Montana, transferred by Osborn to *Rhynchotherium brevidens*. Last right superior molar with trefoils on inner side. One-third natural size.

A, Crown view; A1, inner view; A2, outer view.

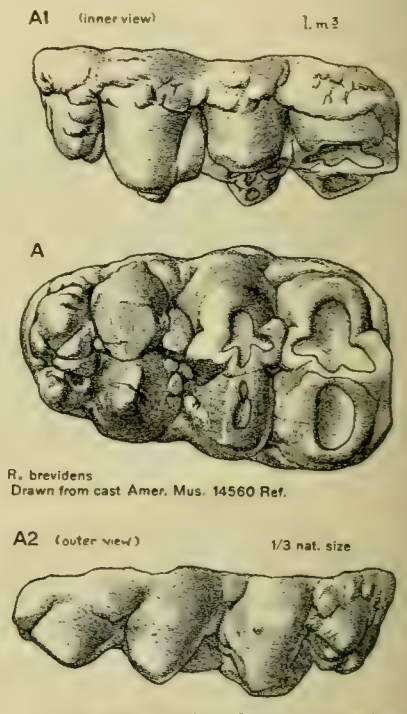
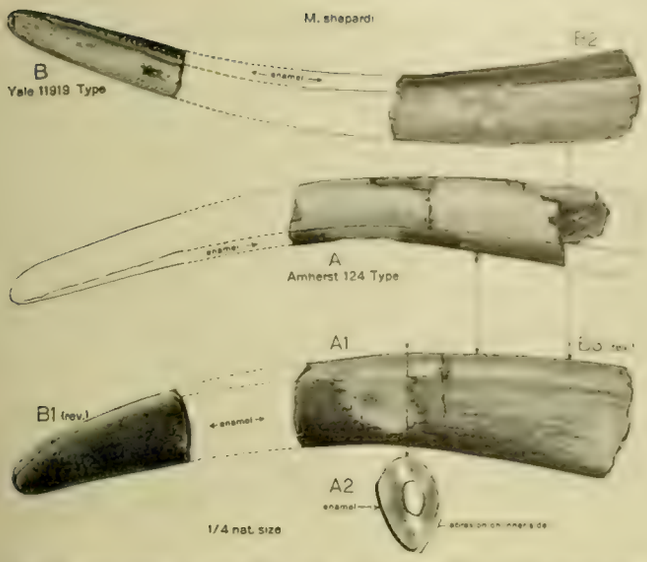


Fig. 458. Referred *Rhynchotherium brevidens*, third superior molar of the left side, l.M³, from eastern Washington. Original in University of Washington. After a cast (Amer. Mus. 14560) presented by Dr. John P. Buwalda. Observe the strong trefoils on the internal side of the crown, the strong internal cingulum; strong protoloph, metaloph, tritoloph, rugose tetartoloph; brachyodont. One-third natural size. Compare with type (Fig. 456) of *Rhynchotherium brevidens*, r.M³, which is reduced to four-ninths natural size; compare also with type of *R. anguirivale* (Fig. 465).



RIGHT AND LEFT SUPERIOR TUSKS OF RHYNCHOTHERIUM SHEPARDI RECONSTRUCTED

Fig. 459. New figures of the type tusks of *Mastodon shepardi* Leidy, as reconstructed by Osborn in 1922, from the Amherst and Yale type specimens belonging to one individual (cast Amer. Mus. 21908).

A, Amherst Mus. 124: Fragment of left superior tusk originally figured by Leidy as the type (see Fig. 460).

A1, B3, Amherst Mus. 124 and Yale Mus. 11919: A composite of the Amherst (A) and Yale (B2) type specimens, the Yale Museum fragment reversed.

A2, Section of Amherst Mus. 124: Leidy's original type fragment showing broad outer enamel band and 'engine turning' of the dentine.

B, End of right upper tusk viewed from above (Yale Mus. 11919).

B1, External view of same fragment.

B2, Proximal fragment of same tusk (Yale Mus. 11919).

Rhynchotherium shepardi Leidy, 1871

Figures 459 and 460

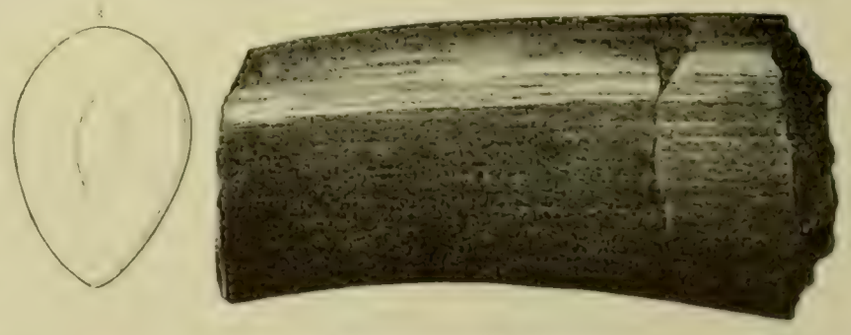
Dry Creek, Stanislaus County, California, Upper (?)Miocene. The Ione formation referred to in the text below, named after Ione village, California, is of late Tertiary age, chiefly non-marine.

This species of the genus *Rhynchotherium* was the first to be discovered in North America, receiving its name "*Mastodon shepardi*" Leidy, 1871, from its original owner. Professor Shepard was mineralogist at Amherst College from about 1851 to 1871. This type has had a remarkable history; two eastern museums, Amherst and Yale, claim the honor of possessing it. When the type tusk fragments from these two museums were brought together through the courtesy of Professor Loomis and Professor Lull, it was found possible to restore both superior tusks, as represented in figure 459.

Mastodon shepardi Leidy, 1871. Note on Mastodon remains in the Warren Museum, the museum at Cambridge, and at Amherst College, and on a new species of Mastodon. Proc. Acad. Nat. Sci., Phila., Vol. XXII (1870), p. 98 (published March 14, 1871). TYPE.—(Leidy, *op. cit.*, p. 98): . . . "fragment of a tusk from 'Dry Creek,' Stanislaus Co., California." Collection of L. G. Yates, Museum of Amherst College, No. 124. (Osborn, 1924): Four fragments of both superior tusks belonging to the same individual, originally collected in Stanislaus County, California (Amherst Museum 124: Yale Museum 11919), as shown in figure 459.

REFERRED "*Mastodon obscurus*" Leidy, 1873, pp. 232, 235, Pl. XXI, figs. 1, 2: "Last lower molar of the left side, natural size. Specimen discovered by Dr. Lorenzo G. Yates, in Contra Costa County, California, and now in the Museum of Amherst College" [cf. A. M. 12388, Fig. 454, also Fig. 469]. This third lower grinding tooth of the left side, figured by Leidy on the same plate with the type tusk of '*M.*' *shepardi*, may be referable to *Rhynchotherium shepardi*, although it belongs to a different individual and comes from another county; it resembles in proportion the *R. anguirivale* type (Fig. 465) as well as in the possession of simple external trefoils.

HORIZON AND LOCALITY.—(Leidy, 1871.1, p. 98): Dry Creek, Stanislaus County, California. Dr. J. C. Merriam (letter, January 2, 1923) writes: "I am in doubt whether we can be sure of the geologic level of Dry Creek, Stanislaus County, California, but I am writing to Dr. Stock to ask if he and Dr. Buwalda will see if together they cannot form some idea of the age of this occurrence." Doctor Stock (letter, January 29, 1923) writes: "Dr. Buwalda and I have gone into the matter of geological occurrence of *Rhynchotherium shepardi*. There is no record here, apparently, no further information than that which may be gleaned from Lindgren's Summary of the Tertiary Gravels of the Sierra Nevada. On Lindgren's map of the northern part of the Sierra Nevada (pl. 1, Prof. Paper 73, U. S. G. S.), the locality cited by Professor Osborn as Dry Creek, Stanislaus County, occurs in an area which has not been mapped. However, it is flanked on each side by a band of Ione [formation] and the inference would be that the mastodon material came from one of the horizons of the Cenozoic sections. I doubt, and Dr. Buwalda concurs with me, that we are in a position at present to determine accurately the horizon from which *R. shepardi* has come." TYPE FIGURE.—Leidy, 1873.1, Pl. XXI, figs. 3, 4.



TYPE OF RHYNCHOTHERIUM SHEPARDI

Fig. 460. Original type figure of *Mastodon shepardi* Leidy, 1871. After Leidy, 1873.1, Pl. XXI, fig. 3 (tusk), fig. 4 (section), Amherst Mus. 124. See new figure 459A, A1, A2.

TYPE DESCRIPTION.—(Leidy, 1871.1, p. 98): "The fragment is six inches in length, is slightly curved in two directions, and in transverse section is ovate with the anterior pole acute. The pulp cavity, opening half the diameter at the broken base of the specimen, extends about half its length to the end. The convex side of the tusk possesses, as in *Mastodon angustidens*, a broad band of

enamel, which reaches from the acute edge more than two-thirds the depth of the surface. The enamel is somewhat rugose and is two-thirds of a line thick. At one spot, towards the smaller end of the fragment, it has been irregularly worn through for the extent of about an inch and a half. The opposite side of the specimen, from the acute edge, has been worn off to an extent about equal to two-fifths of the surface. The broken ends of the fragment exhibit very conspicuously the beautiful arrangement of decussating curved lines so characteristic of the ivory in the tusks of the great proboscidians. The vertical diameter of the base of the fragment is 28 lines, the transverse diameter 19 lines; the vertical diameter at the opposite end is 22 lines, the transverse diameter 16 lines. The entire length of the tusk appears to have been less than two feet. . . . For the name of the species I would propose that of *Mastodon shepardi*, in honor of Prof. C. N. Shepard, whose name has so long been identified with the interests of natural history."

Osborn, 1924: We observe that the original fragment (A, A1, A2) of the left superior tusk, named by Leidy *Mastodon shepardi*, actually represents a *Rhynchotherium shepardi*. Thus we have four type fragments of two tusks belonging to the same individual, originally collected in Stanislaus County, California, loaned for purposes of identification and reconstruction through the courtesy of Dr. F. B. Loomis of Amherst and of Dr. R. S. Lull of Yale. Fortunately, therefore, our search has brought together the type fragments of the two upper tusks of *R. shepardi*, but no additional parts of this animal have been recovered and the actual geologic locality where this type was found is unknown. The lateral compression of the tusk, as shown in A2, leads us to relate this animal to the genus *Rhynchotherium* rather than to *Serridentinus*, although it is important to observe, as in the case of *R. rectidens*, that generic identification by means of the superior tusks alone is not absolutely reliable and it is possible that the species *M. shepardi* may subsequently prove to belong in the *Serridentinus* phylum.

Erroneous References

(Cope, 1893.1).—The specimen from the Blanco formation of Texas *referred* to *Tetrabelodon shepardii* by Cope (1893.1, p. 57, Pl. xv) does not belong to this species and has been renamed by Osborn *Rhynchotherium falconeri*.

(Wagner, 1899).—The jaw from Phillips County, Kansas, in the University of Kansas Museum, described by Wagner (1899, p. 99) as *Tetracaulodon* (*Tetrabelodon*) *Shepardii* Cope (*op. cit.*, Pls. xxiv, xxv), is certainly not a *Rhynchotherium* and consequently cannot be referred to the species *shepardi;* it is referable rather to a species of *Trilophodon*, in view of the measurements and index of the last inferior molar, namely, anteroposterior diameter 180 mm., transverse diameter 64 mm., index 36. Wagner's erroneous reference is undoubtedly due to the erroneous reference given by Cope of *M. shepardi* (Cope, 1893.1, p. 57, Pl. xxiv).

Consequently we know of no original or supplementary material at present which will enable us to amplify the characters of '*Mastodon*' *shepardi* Leidy and positively to determine whether it belongs to *Rhynchotherium* or to *Serridentinus*, unless it be the inferior molars from Contra Costa County, California (Figs. 454, 469).

Rhynchotherium rectidens Osborn, 1923

Figures 461 and 481

Eight miles west of Pawnee Buttes, Weld County, Colorado, Upper Miocene, Pawnee Creek horizon.

As shown in figure 461, the type consists of the right and left superior tusks. These type tusks were found by Dr. W. D. Matthew on August 22, 1901, in the Upper Miocene, Pawnee Creek horizon, Colorado, a locality rendered well known by the explorations of Cope and of Matthew and by the discovery of remains of several species of *Merychippus*, of *Parahippus*, *of Hypohippus*, and of the camels *Protolabis*, *Alticamelus*, and the canid

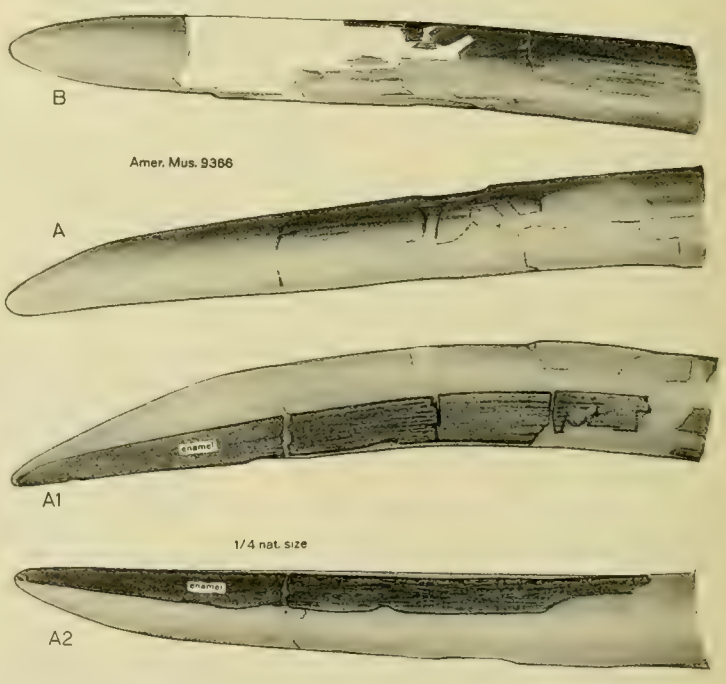


Fig. 461. Type right and left upper tusks of *Rhynchotherium rectidens* Osborn, 1923, from Pawnee Buttes, Upper Miocene of Colorado (Amer. Mus. 9366). One-fourth natural size.

A, Superior view of left upper tusk. A2, Inferior aspect of same.
A1, External view of same. B, Top view of right upper tusk.

Amphicyon. The type of *Mastodon proavus* Cope, which in this Memoir is referred to *Serridentinus proavus*, came from the same locality, and probably from the same level of Pawnee Creek, consequently it is possible that these tusks may be referable to the genus *Serridentinus*. The type description is as follows:

Rhynchotherium rectidens Osborn, 1923. "New Subfamily, Generic, and Specific Stages in the Evolution of the Proboscidea." Amer. Mus. Novitates, No. 99, December 27, 1923, p. 3. Type.—Right and left upper tusks (Amer. Mus. 9366). Horizon and Locality.—Eight miles west of Pawnee Buttes, Weld County, Colorado, on Davis' ranch, Upper Miocene, Pawnee Creek horizon. Type Figure.—Figures 461 and 481 of the present Memoir.

Type Description.—(Osborn, 1923.601, p. 3): "In comparison with the upper tusks of *Rhynchotherium shepardi* Leidy (1) the *R. rectidens* tusks are nearly straight in superior view, while those of *R. shepardi* are curved; (2) the enamel band in *R. rectidens* is much narrower than that in *R. shepardi;* (3) in external view the downcurving of the tusks in *R. rectidens* is much less than that in *R. shepardi.* The specific stage is simpler than the Lower Pliocene *R.*[1] *euhypodon* Cope from the Republican River, Kansas [Nebraska]."

Osborn, 1924: Comparison with the *Rhynchotherium* [=*Blickotherium*] *euhypodon* type from the Republican River beds, Lower Pliocene of Nebraska, proves that *R. rectidens*, like *R. shepardi*, was probably in a Miocene stage of evolution. While the marked lateral *compression* relates these tusks to *Rhynchotherium* rather than to *Serridentinus*, it is well to keep in mind the possibility that the type of *R. rectidens* may be related to a specific form of *Serridentinus* and ultimately prove to be synonymous with the *Serridentinus proavus* of the Pawnee Creek beds.

Tusks.—The following comparative measurements are extremely important, because there are marked similarities in the superior incisive tusks of both *Rhynchotherium* and *Serridentinus:* it is difficult, for example, to distinguish the restored tusks of *Mastodon* [=*Rhynchotherium*] *shepardi* Leidy from the tusks of *Serridentinus productus;* the superior tusks have the same general shape in both genera; the *R. shepardi* tusks, however, are narrower in cross-section, deeper in anteroposterior or vertical section, index 69 to 70; the *S. productus* tusks are relatively broader in transverse section, equally deep in anteroposterior section, index 80–84.

Comparative Diameters and Proportions of Rhynchotherium and Serridentinus Tusks

		Right Tusk			Left Tusk		
	Total length external to jaw	ant.-post. diams.	trans. diams.	Index	ant.-post. diams.	trans. diams.	Index
Rhynchotherium browni type							
Lower tusk broken in mid-section	270+	98	46	47	..	..	..
Rhynchotherium[1] *euhypodon* type							
Superior tusk 8 in. from tip	482(575)	69	52	75	..	..	..
Rhynchotherium shepardi type							
Superior tusk 8 in. from tip	350c	52	36	69	49	35	71
" " 12 in. from tip	....	58	41	70	..	..	..
Rhynchotherium rectidens type							
Superior tusk 8 in. from tip	404	56	47	84	53	47	89
" " 12 in. from tip	....	59	45	76	..	..	..
Serridentinus productus ref.							
Superior tusk 8 in. from tip	412	50	40	80	..	..	..
" " 12 in. from tip	....	37	31	84	..	..	..

6. SYNOPSIS OF SPECIFIC CHARACTERS OF THE PLIOCENE SPECIES

Blickotherium euhypodon[1] Cope, 1884

Figures 450, 453, 462–464, 481

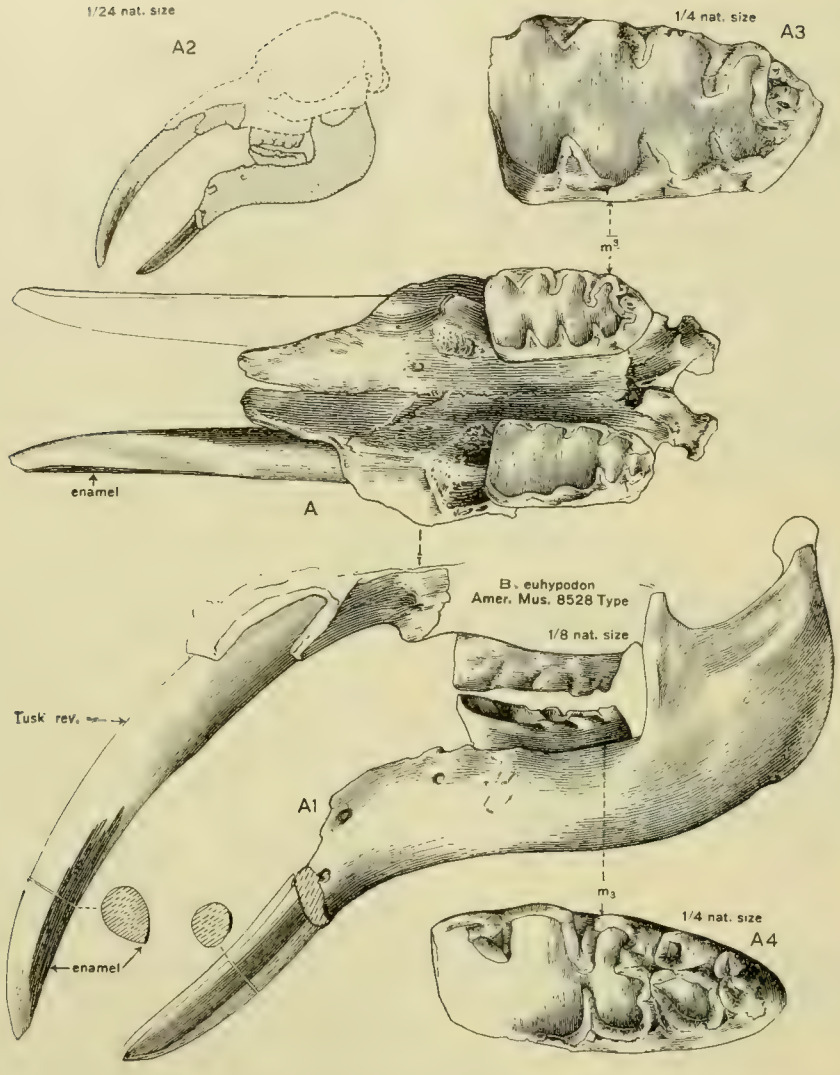
Republican River beds, Lower Pliocene, Trail Cañon, south fork of Driftwood Creek, Hitchcock County, Nebraska.

The type was discovered by one of Cope's collectors, Frank Hazard, near Culbertson, Hitchcock County, Nebraska, on March 23, 1880, and was worked out during the succeeding fortnight, March 23 to April 6, as shown in the Hazard diary now preserved in the American Museum with the Cope Collection. The materials certainly belonging to the type ("Mastodon, specimen No. 9") include half of the lower jaw with M_3, palate with M^3 of both sides, and right superior and left inferior tusks—all comprised in Amer. Mus. Cope Coll. 8528, as represented in our new figure of the type (Fig. 462). Hazard found four other tusks, probably belonging to another individual. He speaks of the lower jaw containing one incisor tooth not articulated (Cope, 1889.2, Pl. xiii—our Fig. 463). The ridge formula is: M 3 $\frac{4\frac{1}{2}}{4\frac{1}{2}}$. M^3 is relatively broad, while M_3 is relatively narrow, a difference of proportion not observable in *Rhynchotherium brevidens* but observed in the third inferior molars of *R. browni* (Fig. 467) and of *R. falconeri* (Fig. 468). Observe the laterally flattened section of the superior incisive tusks in figure 464, which is quite distinct from the ovate section of '*Mastodon*' *shepardi* Leidy, as represented in figures 460 and 459.

The Lower Pliocene type of *Blickotherium euhypodon*, as illustrated in figure 462, is the first specimen recorded in America in which one of the superior tusks and both grinding teeth are positively associated with the ramus of the jaw and the third lower grinder. This specimen is therefore priceless, in enabling us to correlate the characters of the superior and inferior tusks, of the superior and inferior grinding teeth, of the palate, and of the jaw. These characters are clearly displayed in the new type figure (Fig. 462), whereas the original type figures of Cope (Figs. 463, 464) are misleading, especially in the position and restoration of the inferior incisive teeth from another individual, as shown in figure 463 (Pl. xiii), reproduced below. We therefore open this description with the new type figure.

M. [*Mastodon*] *euhypodon* Cope, 1884.1. "The Mastodons of North America." Amer. Nat., Vol. XVIII, 1884, p. 525. Type (fide Cope).—A nearly perfect left mandibular ramus with last molar, M_3, also the entire palate with last superior molars, M^3. There are four tusks, two upper and two lower, each

[1]Referred by Osborn in the present Memoir to the genus *Blickotherium* Frick, 1933, possibly ancestral to *Blickotherium blicki* of Honduras (see Fig. 482, p. 512, below).



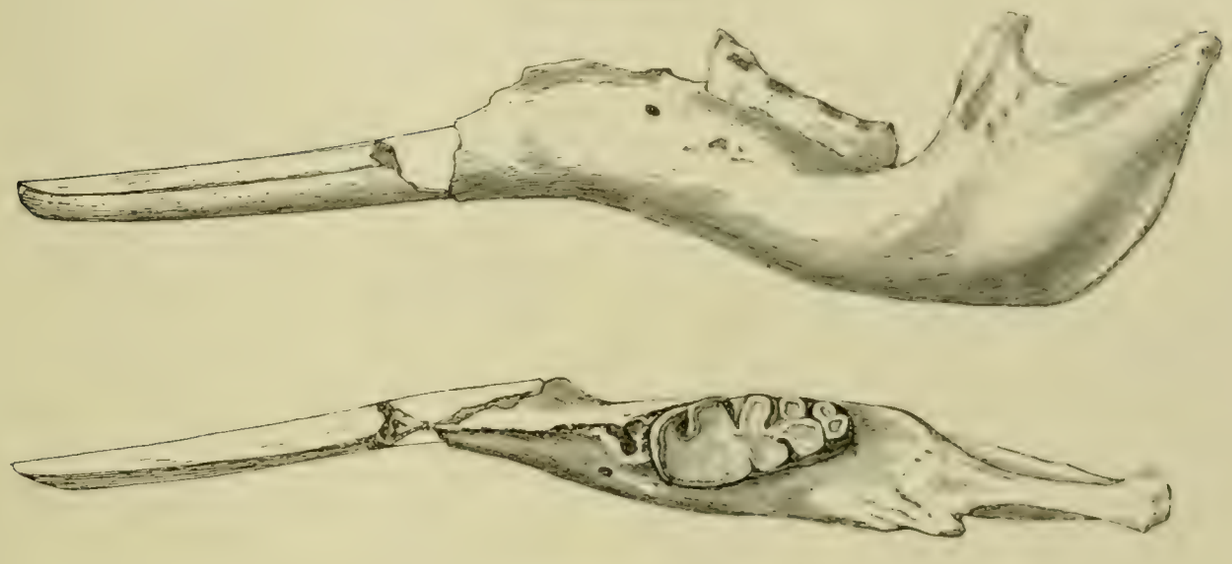
TYPE OF BLICKOTHERIUM EUHYPODON

Fig. 462. New type figure of *Mastodon euhypodon* Cope (Amer. Mus. Cope Coll. 8528), from Trail Cañon, south fork of Driftwood Creek, Hitchcock Co., Neb. Jaws one-eighth natural size; teeth one-fourth natural size; restoration of cranium one twenty-fourth natural size. Observe that it is an aged individual, M^2 erupted, M^3 deeply worn.

A, Palatal view. A1, Left lateral view of skull fragment and jaw with left inferior tusk. A2, Dotted outline of restored skull conjectural, showing upturned inferior incisors. A3, Tetralophodont left M^3. A4, Narrow tetralophodont + left M_3.

with an enamel band on the outer, convex side, corresponding with other Rhynchorostrines, a most important type. Amer. Mus. Cope. Coll. 8528. HORIZON AND LOCALITY.—(Cope, 1889.2, p. 204): "From the Loup Fork bed of Kansas" [i.e., Republican River beds]. The actual locality of the specimen is in Nebraska, Trail Cañon, south fork of Driftwood Creek, Hitchcock County. This geologic level is the *Pliauchenia-Peraceras* zone of Osborn, yielding also the medilongirostral species *Tetralophodon campester*, and is now regarded as the summit of the Lower Pliocene. TYPE FIGURE.—Cope, 1889.2, p. 203, fig. 7, and Pl. XIII [erroneous drawing]. TYPE DESCRIPTION.—(Cope, 1884.1, p. 525): "Founded on a nearly perfect left mandibular ramus with last molar tooth and [left lower] tusk, with entire palate with both last molar teeth and tusks [one tusk now missing]. The superior tusks are small and have an enamel band, and the inferior tusks are large and have an enamel band. Superior tusks compressed; inferior cylindric. The jaws indicate a small species, but the molar teeth are as large as those of the larger American form of *M. angustidens*, and as long as that of *M. ohioticus*, but narrower. Its symphysis is not prolonged. Length of ramus posterior to symphysis, M. .500; of last lower molar, .182; width of do., .75. The mental tusk is much larger than that of *M. productus* or *M. angustidens*. Diameter of its alveolus, .068. Kansas. Frank Hazard."

PLATE XIII



Tetrabelodon euhypodon Cope.

Fig. 463. Type of *Mastodon euhypodon* Cope, 1884, about two-thirteenths natural size. Amer. Mus. Cope Coll. 8528. After Cope, 1889.2, Pl. XIII. Observe more accurate representation of the type left mandible and incisive tusk in figure 462; also four and a half crested third inferior molar. [=*Blickotherium euhypodon*.]

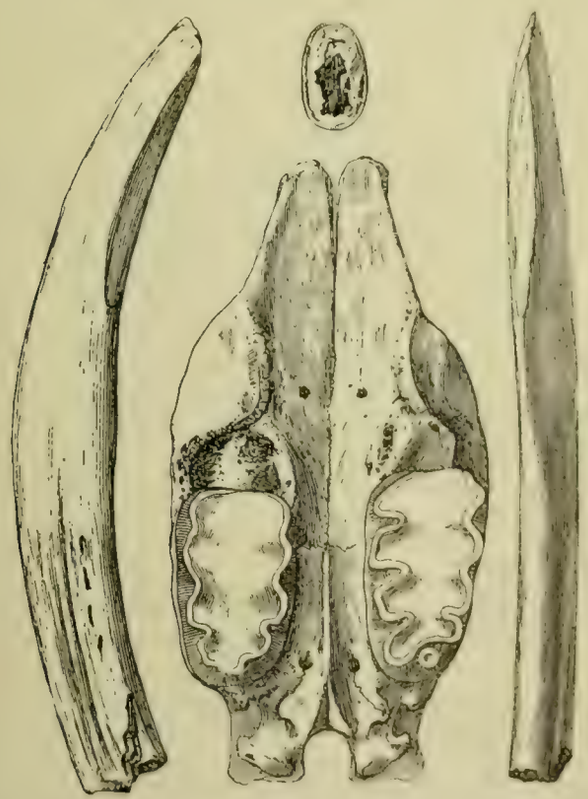


Fig. 7. *Tetrabelodon euhypodon* Cope; Loup Fork bed of Kansas. Palate with superior molars and superior incisors, of individual represented in Plate XIII; one-seventh natural size. Original.

Type of Blickotherium euhypodon

Fig 464. Type figure of *Mastodon euhypodon* Cope, 1884, about two-thirteenths natural size. Amer. Mus. Cope Coll. 8528. After Cope, 1889.2, p. 203, fig. 7, figured as *Tetrabelodon euhypodon*

Cope's Supplementary Description.—(Cope, 1889.2, p. 204): "There are several marked peculiarities in this species. The symphysis is remarkably short, when we consider the large size of the inferior tusks. The superior tusks are remarkably compressed for a considerable part of their length distally, having a vertically oval section."

Osborn, 1924: We observe that Cope's type description above does not correspond with Cope's supplementary description in respect to the proportions and characters of the superior and inferior tusks. Consequently we must restate the characters of the type specimen (Amer. Mus. Cope Coll. 8528) from the existing type materials as identified in figure 462:

Superior tusk, exposed length	482(575) mm.
Anteroposterior (vertical) diameter	85
Transverse diameter	55
Inferior tusk, exposed length	265
Anteroposterior (vertical) diameter	50
Transverse diameter	46
Third superior molar, M^3,	
Anteroposterior diameter	(right) 179–179 (left)
Transverse diameter	(right) 96–103 (left)
Index	(right) 54– 58 (left)
Third inferior molar, M_3,	
Anteroposterior diameter	182 (left)
Transverse diameter	78 (left)
Index	43 (left)

Rhynchotherium anguirivale[1] Osborn, 1926

Figures 394, 465, and 466

Lower Pliocene, Snake Creek B horizon (upper), Sioux County, Nebraska.

In *Rhynchotherium anguirivale* of Lower Pliocene age the third inferior molar (Fig. 465) is larger and more massive, with thicker enamel, than the type of *R.* [*Blickotherium*] *euhypodon*

[1] *Gomphotherium serpentirivale* Hay, 1930, new name, undefined, equals ?synonym of *Rhynchotherium anguirivale* Osborn (see Hay, 1930, p. 639).

(Figs. 462, 463); the rudimentary fifth lobe or pentalophid is slightly more progressive; two conelets are observed on the internal cones (Figs. 465 and 466), unlike *Serridentinus*.

It would appear that *Rhynchotherium anguirivale* was the largest mastodont of Snake Creek B (upper) times. As clearly shown in the composite drawing (Fig. 394), the five quarries of the

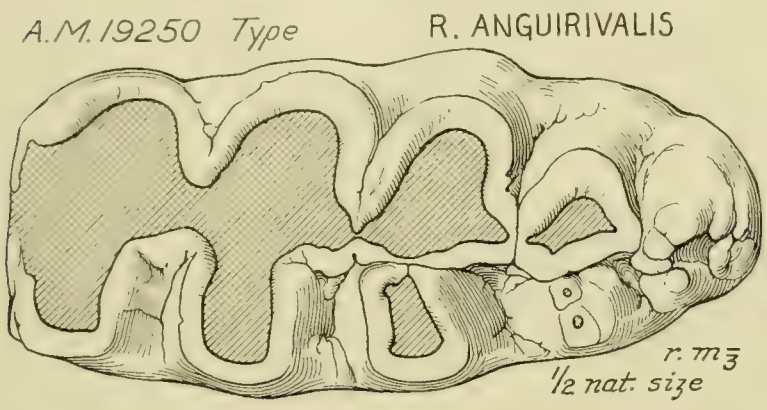


Fig. 465. Type of *Rhynchotherium anguirivale* (Amer. Mus. 19250), Snake Creek, Pliocene of Nebraska. After Osborn, 1926.706 p. 13, fig. 11. One-half natural size. A third inferior molar of the right side, r.M_3. For referred grinders from the same horizon, see figures 394 and 466.

Snake Creek B horizon (upper), of Sioux County, western Nebraska, yield isolated, usually fractured, and partly water-worn grinding teeth and tusks of mastodonts belonging to three different genera and as many species, the contrasting characters of which are represented in this composite drawing (Fig. 394). The grinding teeth of the true Mastodontinæ, specific stage *Pliomastodon matthewi*, are sharply lophoid with the most rudimentary trefoil spur ridges. The grinding teeth of the Serridentinæ, stage *Serridentinus anguirivalis*, are also lophoid with trefoil spurs arising from the internal side of the superior molars. The grinding teeth of the Brevirostrinæ, stage *Stegomastodon nebrascensis*,[1] are by contrast bunodont, ptychodont or much folded, and chœrodont or tuberculated, with single trefoil spurs. The grinding teeth of the Rhynchorostrinæ are bunolophodont with single trefoils, extremely thick enamel, and of surpassing size. Observe the very wide contrast (*a*) between the smooth, thin enamel of *Pliomastodon*, (*b*) the very thick, smooth enamel and blunt cones of *Rhynchotherium*, (*c*) the folded, chœrodont enamel of *Stegomastodon*,[1] (*d*) the thin, high-crested enamel of *Serridentinus*. These contrasts indicate that the Snake Creek B (upper) mastodonts were washed in from many different local feeding habitats.

Rhynchotherium anguirivalis Osborn, 1926. "Additional New Genera and Species of the Mastodontoid Proboscidea." Amer. Mus. Novitates, No. 238, Nov. 30, p. 13. Type.—Amer. Mus. 19250. A well-worn third right inferior molar, r.M_3. Horizon and Locality.—Snake Creek B horizon (upper), Lower Pliocene, Sioux County, western Nebraska, Quarry 3 (Olcott Hill). Type Figure.—*Op. cit.*, Osborn, 1926.706, p. 13, fig. 11.

Type Description.—(Osborn, 1926.706, p. 13): (1) Type third inferior molar with four and a third ridge-crests, tetartolophid much narrower than tritolophid, the narrow pentalophid represented by four irregular conelets. (2) Number of superior ridge-crests uncertain, probably the same as in the *Rhynchotherium brevidens* type. (3) Enamel extremely thick and massive, without folding. (4) Inferior molars with single external median trefoils, superior molars with single internal median trefoils, no trace of double trefoils. (5) Molars low crowned, brachyodont. (6) Meas-

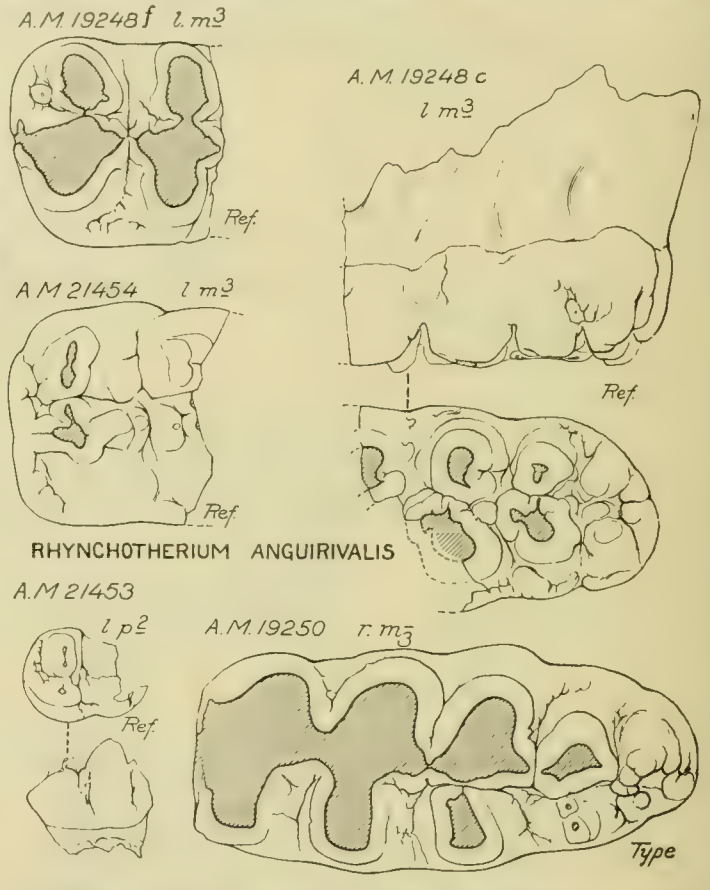


Fig. 466. Type and referred grinding teeth of *Rhynchotherium anguirivale* from the Snake Creek B horizon (upper), Sioux County, western Nebraska, one-third natural size. Compare figure 394.

Amer. Mus. 19250, type, a well-worn right third inferior grinding tooth, r.M_3, exhibiting four and a half ridge-crests.

Amer. Mus. 19248f, referred, anterior half of a well-worn left third superior molar, l.M^3.

Amer. Mus. 21454, referred, anterior portion of a less worn left third superior molar, l.M^3.

Amer. Mus. 19248c, referred, posterior half of a left third superior molar, l.M^3, showing part of three crests and a half-formed posterior crest.

Amer. Mus. 21453, referred, left second superior premolar, l.P^2.

urements of r.M_3, ap. 214 mm., tr. max. 98 mm., of l.M^3, ap. 163e mm., tr. max. 83 mm.

These specific characters and measurements fully serve to distinguish *Rhynchotherium anguirivale* of the Snake Creek of Nebraska from *R. brevidens* of Montana and Washington; it would appear that the third superior molar in *R. anguirivale* is somewhat less broad and massive than that of *R. brevidens;* it would also appear possible that the third superior molar of *R. anguirivale* has the fourth additional crest or tetartoloph more fully

[1] *Stegomastodon nebrascensis* now proves to be *Serridentinus* (*Ocalientinus*?) *nebrascensis*, subfamily Serridentinæ (p. 473 above).

developed than in *R. brevidens*, but on this point we must await the evidence which will be afforded by a complete third superior molar; the third inferior molar resembles in its stage of development that of *R.* [*Blickotherium*] *euhypodon* (Fig. 462).

RHYNCHOROSTRINES OF MEXICO

The Middle Miocene to Upper Pliocene Rhynchorostrines, namely, *Rhynchotherium spenceri* of Egypt, *R. chinjiense* of India, *R. brevidens* of Montana, *R. shepardi* of northern California, *R. rectidens* of Colorado, *R.* [*Blickotherium*] *euhypodon* of central Nebraska, *R. anguirivale* of western Nebraska, and *R. shepardi edense* of southern California, are the rarest of all the bunomastodonts, probably because of forest-living habits.

Rhynchotherium tlascalæ Osborn, 1918, 1921

Figures 447, 448, 477, 478, and 482

Probably Upper Pliocene. Type from Tlascala, Valley of Mexico.

The reader is referred to pages 475 and 477 of the present Memoir for the first mention by Falconer (1863, pp. 55, 56, 1868, Vol. II, p. 74) of Tlascala, Valley of Mexico, as the type locality of *Rhynchotherium*; also to page 507 for supplementary observations.

We now pass to the more progressive Upper Pliocene *Rhynchotherium tlascalæ* of the Valley of Mexico recorded from Tlascala (Falconer, 1863, see pages 475, 477 of the present Memoir) and originally characterized by Falconer as "a magnificent specimen of an adult lower jaw of *Mastodon Andium*, invested with a very massive and elongated incisive beak, deflected downwards, and retaining the basal section of one very large incisor" (Fig. 448).

The name *tlascalæ* was first used in 1918 (Osborn, 1918.468, table opp. p. 134). On a subsequent page (p. 135) the name appears *tlaxcalæ*. In the definition and neotype[1] description of the species (Osborn, 1921.515, pp. 5, 6) the name also appears as *tlascalæ*. The name *tlaxcalæ* therefore is a *nomen nudum*. The appropriateness of this name arises from the fact that the original genotype lower jaw (cast in Muséum d'Histoire Naturelle of Geneva, Fig. 448) is said to have come from near Tlascala, Valley of Mexico; the neotype[1] lower jaw (Amer. Mus. 15550) comes from another locality, namely, San José de Pimas, Sonora, Mexico.

Rhynchotherium tlascalæ Osborn, 1918. "A Long-Jawed Mastodon Skeleton from South Dakota and Phylogeny of the Proboscidea." Bull. Geol. Soc. Amer., Vol. XXIX, March, pp. 134, 135.

Rhynchotherium tlascalæ Osborn, 1921. "The Evolution, Phylogeny, and Classification of the Proboscidea." Amer. Mus. Novitates, No. 1, pp. 5, 6.

TYPE.—Lower jaw from the Valley of Mexico, said to have come from near Tlascala; the cast in the Geneva Museum is duplicated in the American Museum (Amer. Mus. 27003). NEOTYPE[1].—Lower jaw (Amer. Mus. 15550) chosen by Osborn (1921.515, pp. 5, 6) as a neotype of the genus and species *Rhynchotherium tlascalæ* Osborn, 1918. HORIZON AND LOCALITY OF NEOTYPE.—Found a quarter of a mile above San José de Pimas, Sonora, Mexico, by Dr. Barnum Brown during a reconnoissance for the American Museum in 1911, and believed to correspond with the misplaced or lost cast referred to by Falconer as in the Genoa Museum (Geneva Museum), and which he (Falconer) described as the type of his genus *Rhynchotherium*. NEOTYPE FIGURE.—Osborn, 1921.515, p. 6, fig. 2C (=*R. browni* sp. nov., Fig. 450C of the present Memoir).

A second right superior molar, r.M^2 (Amer. Mus. 15550), belonging to the neotype, presents the very broad and short dimensions (ap. 134 mm., tr. 95 mm., index 71) characteristic of this genus; it also exhibits three transverse ridge-crests, with very thick enamel, single internal trefoils, and crenulated spur extending outwards from the postero-internal border; it is mounted opposite l.M_2 of the neotype jaw.

NEOTYPE[1] DESCRIPTION.—(Osborn, 1921.515, pp. 5, 6): "The type of this subfamily (*Rhynchotherium* Falconer, 1868) is a cast (observed in the Genoa [Geneva] Museum by Falconer) of a lower jaw from the Valley of Mexico; the jaw at the time had no specific or generic name. The original genotype may be termed *Rhynchotherium tlascalæ*, new species, from the locality Tlascala. A similar [neotype[1]] specimen [Amer. Mus. 15550] from Mexico is in the American Museum (Fig. 2*C*). The present known range of these animals is Mexico (*R. tlascalæ*), California (*R. shepardi* Leidy), Colorado [Montana] (*R. brevidens* Cope), and Kansas [Nebraska] (*R. euhypodon* Cope). . . . The maxilla is partly downturned, as well as the mandibular symphysis. Both the superior and inferior incisors are laterally compressed, bending downward and outward. The grinding teeth remain relatively simple, brachyodont, with posterior grinders not exceeding four and a half crests. The intermediate grinders are trilophodont. The grinding series is reduced to $\frac{3}{2}$, $\frac{1}{1}$ as in *M. mirificus*."

Osborn, 1924: The neotype[1] jaw of *Rhynchotherium tlascalæ* (Amer. Mus. 15550) collected by Mr. Brown near San José de Pimas, Sonora, Mexico, in 1911, is the finest jaw pertaining to this genus which we possess and adds a number of interesting and significant characters. First, we observe that the rostrum is short and sharply deflected (unlike that of *Trilophodon dinotherioides*, Fig. 453) and forms a very firm insertion for the inferior incisive tusks, each of which is provided with a very distinct enamel band. These tusks are slightly upcurved or concave on the superior surface and correspondingly convex on the inferior surface; this curvature affords the tusks greater strength in the uprooting habits of the animal. As seen from above (Fig. 467 A1) the inferior tusks slightly converge from each other so that they must have been spread apart at the extremities.

The superior view gives an excellent impression of the short symphysis, in wide contrast to the elongate symphysis in all species of *Trilophodon*. At the age of this individual (see A1, A2) the anterior grinders, M_1, are greatly worn, the median grinders, M_2, are less worn, and in the posterior grinders the protolophid only is worn. The third inferior molar, M_3, is relatively much narrower than in *Rhynchotherium brevidens* and might readily be mistaken as pertaining to a true species of *Trilophodon;* it has single external trefoils, no internal trefoils; the crown is brachyodont; both the intermediate molars, M_{1-2}, are trilophodont. Consequently this entire inferior dentition would naturally be referred to a member of the genus *Trilophodon*, that is, without the knowledge of the highly characteristic rostrum and the unique lower incisive tusks with their distinct enamel bands. In the table above the measurements and

[1]Made the type in the present Memoir of *Rhynchotherium browni* (see p. 494, also Figs. 448, 452, 467, 478, 482).

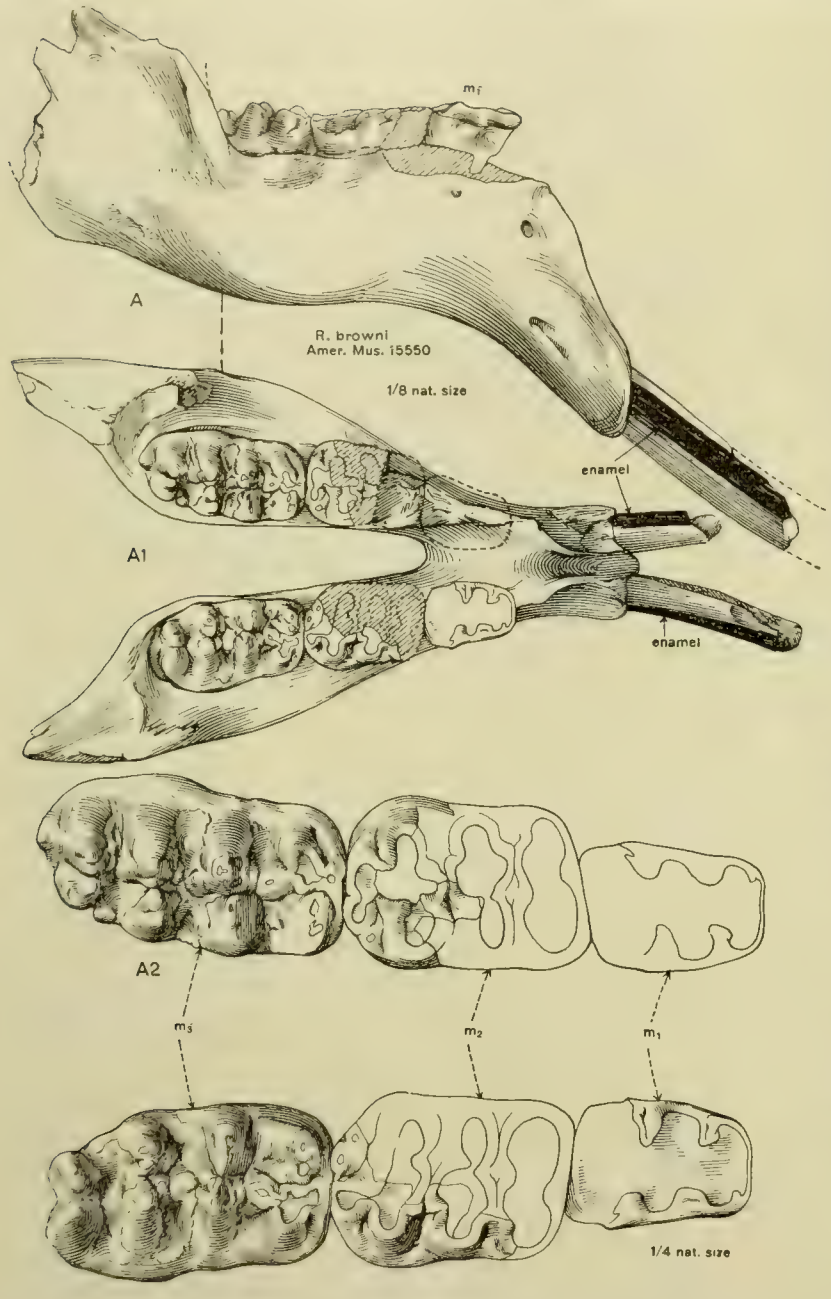


Fig. 467. Type jaw of *Rhynchotherium browni* sp. nov., formerly (1921) Osborn's neotype of *Rhynchotherium tlascalæ* (Amer. Mus. 15550), from near San José de Pimas, Sonora, Mexico. Observe lateral enamel band on slightly upcurved inferior tusks; also ridge formula, namely, M $1\frac{}{3}$, M $2\frac{}{3\,1/4}$ M $3\frac{}{4\,1/3}$. Trefoils on outer side only; crown relatively narrow, elongate. Observe two posterior conelets on M_2 (= tetartolophid).

A, Right lateral aspect; A1, superior aspect. Both one-eighth natural size.

A2, Grinding teeth enlarged to one-fourth natural size.

indices of M_3 of the left side are compared with those of *Rhynchotherium* [*Blickotherium*] *euhypodon* and *R. falconeri;* in the present instance the measurements of the molars are as follows:

	R. browni			*R. tlascalæ*
Inferior Molars	r.M_1	r.M_2	r.M_3	l.M_3
Anteroposterior diameter	98	136e	176	180e
Transverse diameter	67	100	96	99

Rhynchotherium browni sp. nov.

Figures 448, 452, 467, 478, 482

From San José de Pimas, Sonora, Mexico. Upper Pliocene.

The mandible shown in the adjacent figure 467, described as the neotype (Osborn, 1921.515, pp. 5, 6, Fig. 2C) of *Rhynchotherium tlascalæ*, now proves, on comparison with the rediscovered type as shown in the frontispiece to the present chapter (Fig. 448) and still more clearly in the comparative mandible figure (Fig. 482B), to be entirely different in proportions from the genotype of *Rhynchotherium tlascalæ* (Fig. 482A). Consequently it can no longer serve as a neotype but may be selected as the type of a new species, *Rhynchotherium browni*, named in honor of Dr. Barnum Brown, in further recognition of his fine explorations in Mexico. This type mandible of *R. browni* is figured in comparison with the much more elongate mandible of *R. tlascalæ*, also in comparison with the more abbreviate mandible of *R. falconeri*, in figures 478 and 482.

To the full neotype description on the previous page may be added the characterization given in the legends of figures 478 and 482, namely:

Specific Characters.—Mandible relatively elongate as compared with *Rhynchotherium falconeri* (482D), symphysis obliquely depressed, relatively short, incisors laterally compressed or deeply oval, with broad external enamel band. M_1 subtrilophoid with rudimentary trilophid, ap. 98 mm., tr. 67 mm., index 68; M_2 fully trilophoid, with rudimentary basal cone, ap. 136e mm., tr. 100 mm., index 74e; M_3 tetralophoid, with narrow two-coned tetartolophid, ap. 176 mm., tr. 96 mm., index 55. Ramus stout.

Horizon.—Of especial interest are the notes of Barnum Brown as to the discovery of the specimen, as follows: The mandible and upper molar were exposed in the cut bank of a stream and apparently there had been an associated skull, but a flood a short time previously had washed the skull away and destroyed it.

Rhynchotherium falconeri Osborn, 1923

Figures 453, 468, 478, and 482

Upper Pliocene, Blanco formation, Mt. Blanco, Llano Estacado, Texas.

Rhynchotherium falconeri (Fig. 468A) appears to be the most progressive species of Rhynchorostrine in the abbreviated and sharply downturned rostrum, which is decidedly shorter than the rostrum of *R. browni* (Fig. 467A); the four crested third inferior molars (Fig. 468A1), on the contrary, are somewhat less progressive than the corresponding teeth in *R. browni* (Fig. 467) and *R. anguirivale* (Fig. 465); the thickened enamel, prominent external trefoils, and double conelets on the internal cones appear to be very similar in all three species, namely, *R. anguirivale* (Fig. 465), *R. browni* (Fig. 467), and *R. falconeri* (Fig. 468). Consequently *R. falconeri* appears to be one of the last representatives of its race.

This fine type jaw (Amer. Mus. Cope Coll. 8532) was originally described and figured by Cope as *Tetrabelodon shepardii* Leidy (Cope, 1893.1, Pl. xv). On recognition by Osborn of the presence of a number of types of *Rhynchotherium* in the American formations, all the rhynchorostrine characters were observed in this jaw and

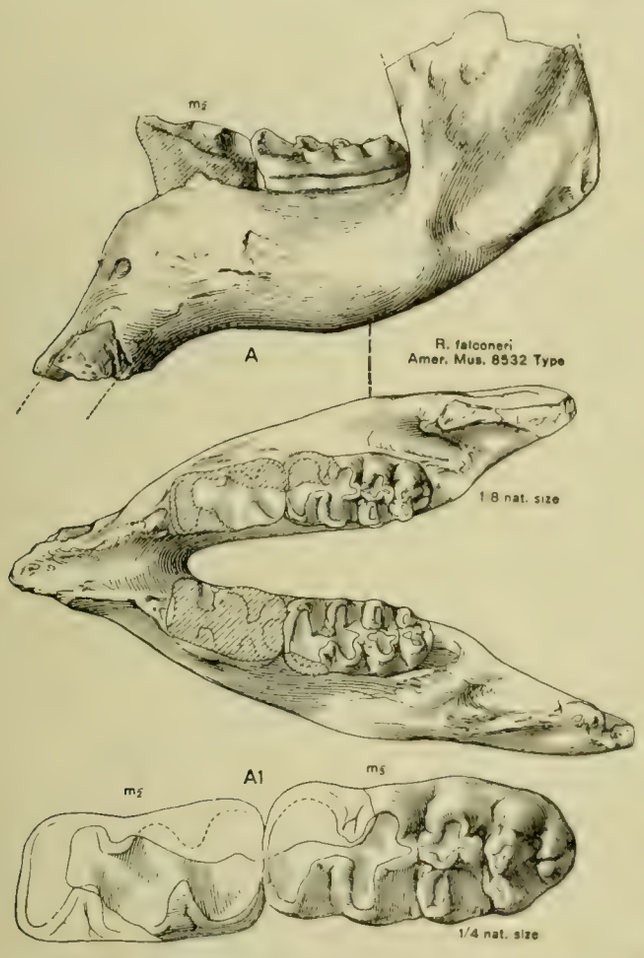


Fig. 468. Type jaw of *Rhynchotherium falconeri* Osborn, 1923 (Amer. Mus. Cope Coll. 8532), found at Mt. Blanco, Llano Estacado, Texas. Jaws (A) one-eighth natural size; teeth (A1) one-fourth natural size. Compare Cope, 1893.1, Pl. xv, figured as "*Tetrabelodon shepardii*, Leidy."

Osborn thereupon made it the type of a new species, *Rhynchotherium falconeri*, named in honor of Dr. Hugh Falconer who first recognized the generic distinctions of *Rhynchotherium*. The type description is as follows:

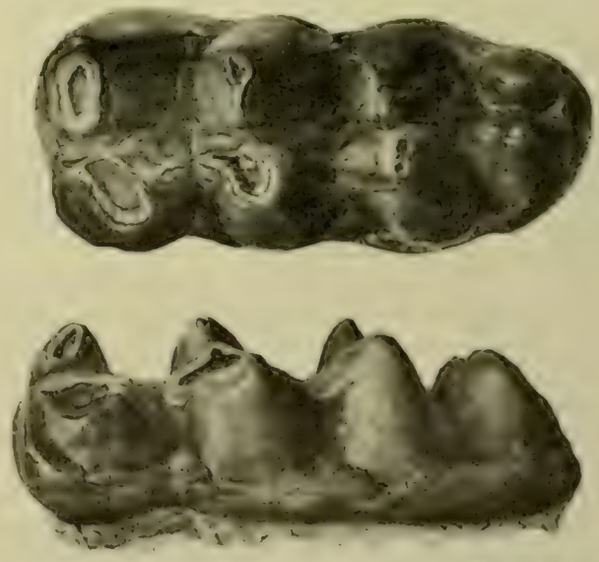
Rhynchotherium falconeri Osborn, 1923.601. "New Subfamily, Generic, and Specific Stages in the Evolution of the Proboscidea." Amer. Mus. Novitates, No. 99, December 27, pp. 3, 4. TYPE.—A lower jaw (Amer. Mus. Cope Coll. 8532). HORIZON AND LOCALITY.—Found at Mt. Blanco, Llano Estacado, Texas, Blanco formation, Upper Pliocene. TYPE FIGURE.—Figure 468 of the present Memoir. Originally figured by Cope in 1893 (Cope 1893.1, Pl. xv) as *Tetrabelodon shepardii* Leidy.

TYPE DESCRIPTION.—(Osborn, 1923.601, pp. 3, 4): "Type, a lower jaw (Amer. Mus. Cope Coll. 8532) found at Mt. Blanco, Llano Estacado, Texas. Upper Pliocene. The type individual was of advanced years; the outer face of the left lower incisor is abraded and no enamel is seen; M_2 trilophodont, M_3 tetralophodont, with external trefoils; jaws stout, lower beak sharply downcurved. Named in honor of Hugh Falconer who first recognized the generic distinctness of *Rhynchotherium*."

It is important to compare the measurements and indices of M_3 with those of the corresponding tooth of *R.* [*Blickotherium*] *euhypodon* (Fig. 462), *R. browni* (Fig. 467), and *R. chinjiense* (Fig. 476).

THIRD LEFT INFERIOR MOLAR	*R.* [*B.*] *euhypodon*	*R. browni*	*R. falconeri*	*R. chinjiense*
Anteroposterior diameter	182	176	168	200
Greatest transverse diameter	78	96	80	92
Breadth-length index	43	55	48	46

Osborn, 1924: The type of the species *Rhynchotherium falconeri* is a thoroughly characteristic specimen; the rostrum is very short and sharply deflected and accords closely with Falconer's description of the genotype jaw of *Rhynchotherium*. The individual is of advanced years, the crown of M_2 being thoroughly abraded, while all four crests of M_3 are coming into use. We observe that the outer face of the left inferior incisor (A) is abraded so that no enamel appears, the enamel band being worn or broken away. The pattern of the grinding teeth is typical of *Rhynchotherium*, namely, M_2 trilophodont, M_3 tetralophodont, external trefoils and no internal or external cingula; a rudimentary pair of cones suggests the beginnings of a pentalophid.



RHYNCHOTHERIUM FROM CONTRA COSTA COUNTY, CALIFORNIA

Fig. 469. "Last lower molar of the left side," l.M_3 (Amherst Coll.), from Oak Springs, Contra Costa County, California, referred by Leidy to '*Mastodon obscurus*.' Crown and outer views. After Leidy, 1873, Pl. xxi, figs. 1, 2; see also page 232. Compare figure 454 of the present Memoir.

ERRATUM, JUNE, 1931

The following description by Osborn of Rhynchotherium shepardi edense, based on the grinding teeth (Fig. 470), is erroneous in including as a paratype the superior incisive tusks (Figs. 471, 523) which prove to belong to a distinct genus and species (Cordillerion edensis), as fully described in the succeeding chapter (XII). The reader is therefore warned to concentrate on the description and measurements of the grinding teeth only, as representative of Rhynchotherium, and to disregard the "finely preserved [superior] rostrum and tusks" (Figs. 471, 523) which are now transferred to, and correctly described in, Chapter XII as the type of Cordillerion edensis.

Rhynchotherium shepardi edense Frick, 1921

Figures 470, 473, 474, 477–479, 481, 482

Eden formation, Mt. Eden Hot Springs, San Bernardino County, southern California. Upper Pliocene, but somewhat more ancient geologically than the Blanco (*fide* Frick, 1921). See page 507 for supplementary observations.

Syn.: *Rhynchotherium paredensis* Osborn, 1929.

The type of the species *edensis* was first described by Frick in 1921 as a subspecies of *Trilophodon* (*Tetrabelodon*) *shepardi* from the specimens illustrated in figures 470 and 471 of the present Memoir. On the recovery from the same horizon of the complete rostrum and tusks (portions of which were described in Frick's bulletin of 1921), Osborn (1922.564) renamed this animal *Dibelodon edensis* (now, 1935 = *Cordillerion edensis*). Subsequently Frick (1926, p. 169) referred to the animal as *?Rhynchotherium* (*Dibelodon*) *edensis*. In the present Memoir, Osborn renames the animal *Rhynchotherium shepardi edense*.

HISTORY.—The superb type specimens (Fig. 470) of *R. shep. edense* were described by Frick in 1921. The complete rostrum and tusks of *Cordillerion* (Osborn, 1922.564—Fig. 523, A1, A2, of the present Memoir) confirm the evidence afforded by Hay's types of *Gomphotherium gratum*, *Anancus orarius*, and *A. defloccatus*, as well as Gidley's type of *Anancus bensonensis*, of the presence of the genus *Cordillerion* in the southwestern part of the United States. The admirable figures of the trilophodont grinding teeth reproduced in the original type figure (Fig. 470) are shown to compare closely with those of *Rhynchotherium*. But the closest resemblance to *Cordillerion* is afforded by the finely preserved rostrum and tusks reproduced in figure 523 (A1, A2) side by side with those of *Cordillerion andium* (B).

When the type maxillaries and M^3 (Fig. 470) were first discovered, the three-crested intermediate grinders with single trefoils naturally led to its reference to the genus *Trilophodon*, and the broken portion of a tusk with single enamel band suggested its relationship to *Mastodon shepardi* Leidy; consequently it was described by Frick as *Trilophodon* (*Tetrabelodon*) *shepardi edensis*. When the characters of the animal became more fully known by the recovery of the distal portions of the tusks (Fig. 523) referred to in Frick's original description (footnote, p. 408) and regarded as presumably of the same individual as the type, these tusks were described by Osborn as belonging to *Dibelodon edensis*, because of the spiral enamel band, a term now replaced by *Cordillerion edensis*.

FRICK, 1926.—In a second communication (1926, pp. 169–176) Frick reviewed the history of these specimens from the Eden quarry and made the important additional observation of the presence in the same quarry of "an immature mandible with well-developed, downward-deflected beak and tusk, and a slightly more immature maxillary specimen with dentition of apparently corresponding form" resembling *Rhynchotherium*. Consequently he felt it preferable (*op. cit.*, p. 171) to refer all the Eden material to the genus *Rhynchotherium*. Osborn erroneously (1929.797, p. 6) made this "immature mandible" and maxillary specimen (Fig. 474) the type of *Rhynchotherium paredensis* which now proves to be a synonym of *R. shepardi edense*.

FRICK'S ORIGINAL DESCRIPTION OF 1921

Trilophodon (*Tetrabelodon*) *shepardi edensis* Frick, 1921. "Extinct Vertebrate Faunas of the Badlands of Bautista Creek and San Timoteo Cañon, Southern California." Univ. Calif. Publ., Geology, Vol. XII, No. 5, December 28, 1921, pp. 405–409. TYPE.—(*Op. cit.*, p. 405): "The portion of a skull and posterior maxillaries, containing the last molar of the left side and a section of that of the right side, Univ. Calif. Coll. Vert. Pal. no. 23501 (fig. 160); two associated molars from the left and the right side respectively, Univ. Calif. Coll. Vert. Pal. 23503, 23504 (figs. 164, 162); and portions of premaxilla and tusks, Univ. Calif. Coll. Vert. Pal. no. 24047 (pl. 50), all from Univ. Calif. loc. 3269. [Univ. Calif. 24047 = *Cordillerion edensis* type.]"

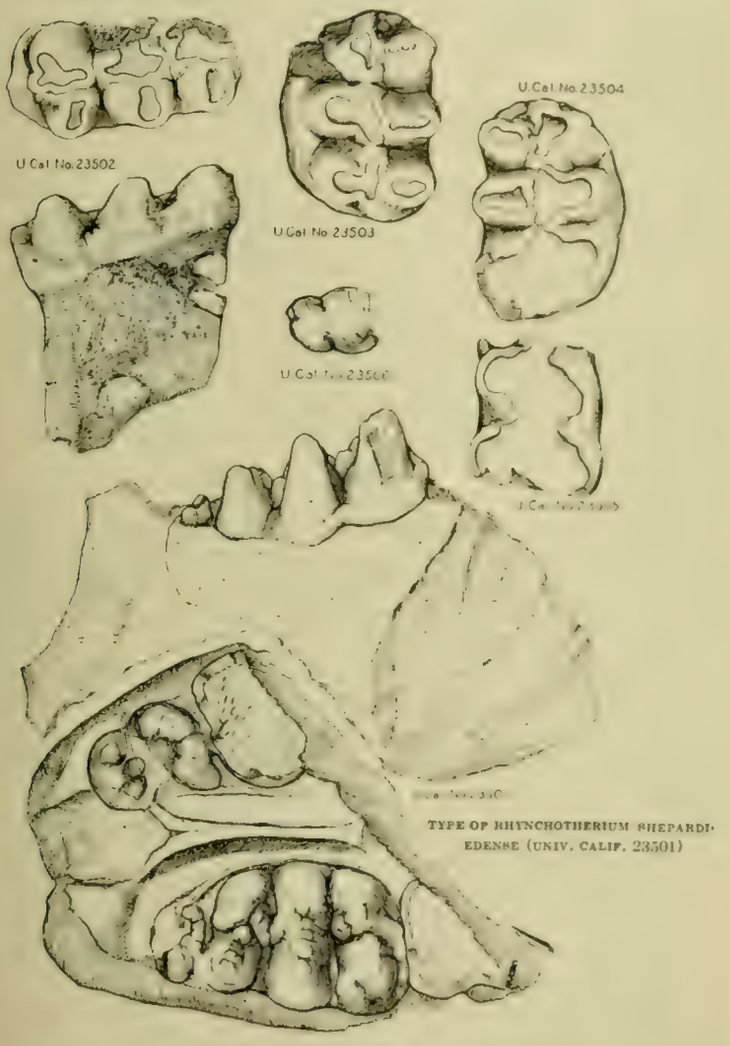
"REFERRED MATERIAL.—A lower molar, no. 23502 (fig. 165); portions of a worn upper molar, no. 23505 (fig. 161); parts of three worn molars, nos. 24049, 23507; a small premolar, no. 23506 (fig. 163); the distal portion of a small tusk, no. 24050 (fig. 159); the proximal section of a large tusk (specimen not retained, loc. 3265); portions of the supraorbital ridge, no. 24051, loc. 3266, of two scapulæ, and various limb and foot elements. All in Univ. Calif. Coll. Vert. Pal.; all from Univ. Calif. loc. 3269, unless otherwise specified."

"CHARACTERS.—The last molar with but four main transverse crests, the intermediate molars with three; the comparative simplicity of the tubercular arrangement, the lack of lateral cingula, and small size of the fourth crest and posterior extremity of the last molar; in moderately abraded teeth, the uniform trefoil character of the pattern of the outer lobes in the upper and of the inner lobes in the lower, and the single oval form of the corresponding opposite lobes in both. . . . [p. 409] *Comparison.*—In the three crests of the intermediate, the four crests of the last molars, and the simple pattern of the tubercles the Eden specimens differ markedly from the complex four-crested intermediate, and six-crested last molars of *Tetralophodon mirificus* Leidy of the Niobrara and *T. campester* Cope of the Blanco. In the presence of but three transverse crests in the intermediate teeth, the new material comes within Matthew's recent definition of the genus *Trilophodon* [Footnote: 'Matthew, W. D. Tertiary Mammalia Cope and Matthew, explanation plate 120. 1915.'] as distinguished from *Tetralophodon*. The Eden teeth lack the elaborated complex pattern and tuberculated cingula of *Trilophodon floridanus* Leidy.

The last molar of the new type specimen somewhat suggests the last lower molar from the San Joaquin Valley of California described by Leidy and tentatively referred by him to his type *Tetrabelodon shepardi* [Footnote, 'Leidy, Jos. Proc. Acad. Nat. Sci. Phil., pp. 98 and 99. Sept., 1870, and U. S. G. S. of Terrs., vol. V, p. 232. 1873.']. The resemblance is marked in the four specimens, as do also the associated four lobed last molar and three lobed intermediate molar from Thousand Creek, Nevada (illustrated *l.c.* Merriam, vol. 6, pl. 33).'] Moreover, the tusks of the present specimen show the enamelled band noted by Leidy in his original description, which was based on the six inch section of tusk from Dry Creek, Stanislaus County [Footnote: 'A similar partial enamel covering has been noted on the fragments of two large tusks from the upper Miocene of Nevada (*l.c.* Merriam, vol. 9, p. 189).'] . . . For convenience in future reference, the Eden form is here referred to *T. shepardi* as a new subspecies under the name of the locality, *Trilophodon shepardi edensis.*"

Horizon and Locality.—In the full characterization and description of this important specimen (Frick, 1921, pp. 405–409), accompanied by characteristic figures which are here reproduced, Frick synchronizes the Eden beds (pp. 285–289 and Folder 1) with the Rattlesnake, Ore., and Thousand Creek, Nev., horizons, and the Snake Creek of western Nebraska distinguished by an abundant plains fauna of *Pliohippus* and of *Hipparion.* The type locality (p. 282) is Mt. Eden Hot Springs, San Bernardino County, southern California, on the southeastern edge of the San Timoteo badlands (see United States Geological Survey, Elsinore Quadrangle sheet, southern California).

Geologic Age of the Eden Horizon.—The discovery of *R. shepardi edense* in the Eden horizon is one of the most important and interesting in the recent history of American palæontology, because through the careful researches of Frick (1921) we are able to establish an age correlation of very great value with other Pliocene faunas mapped by Frick in figure 472, such as Rattlesnake,



Type of Rhynchotherium shepardi edense (Left, Fig. 470) and of Cordillerion edensis (Right, Fig. 471)

Fig. 470. Original type figures of the grinding teeth of *Trilophodon shepardi edense* Frick, 1921. After Frick, 1921, p. 406, figs. 160–165, one-third natural size. [=*Rhynchotherium shepardi edense.*] See note in caption to figure 471 opposite.

(160): "The portion of a skull and posterior maxillaries. . . Univ. Calif. Coll. Vert. Pal. no. 23501."

(164, 162): . . . "two associated molars from the left and the right side respectively, Univ. Calif. Coll. Vert. Pal. 23503, 23504."

Fig. 471. Tusks originally referred to *Trilophodon shepardi edensis* Frick. After Frick, 1921, Pl. L, figs. 1 and 2.

These premaxillæ and tusks (Univ. Calif. Coll. Vert. Pal. 24047, Univ. Calif. loc. 3269), as fully known and restored in Fig. 523 (Chap. XII), now become the type of *Cordillerion edensis.*

Note. Compare l.M^3 (Fig. 470) of *R. shepardi edense* type (150×80 mm.) with r.M^3 (Fig. 475) of *R. francisi* type (147×100 mm.).

well separated cross crests, in the very rudimentary heel of the last molar, and in the trefoil pattern exhibited by the outer halves of the transverse crests of the worn teeth and the small oval pattern of the inner halves. [Footnote: 'A four-crested last lower molar with rudimentary heel, from Oregon (Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, p. 134, fig. 3) somewhat suggests the present Chanac-Etchegoin, Thousand Creek, and Snake Creek B (upper), the proboscidean fauna of which is carefully listed in Chapter VI (Mastodontinæ) and Chapter X (Serridentinæ) of the present Memoir.

(1) Peccaries.—The Eden species *Prosthennops edensis* is more progressive than that of Snake Creek B, but less progressive

than that of Thousand Creek, while the larger peccary (*Platygonus* sp.) suggests a similar stage to that found in the Blanco. (2) Camels.—The *Pliauchenia merriami* of the Eden is more progressive than any of the apparently more primitive Snake Creek camels. (3) Proboscidea.—No comparison can be made, because *Cordillerion* and *Rhynchotherium* are the only mastodonts found in the Eden and cannot be compared with the *Pliomastodon* and *Serridentinus* of the Snake Creek. (4) The absence of strepsicerine antelopes, of rhinoceroses, and of *Hipparion* in the Eden may either indicate local facies or a more recent geologic age. (5) Equines.—Among the species of *Pliohippus*, one greatly resembles *P. spectans* of the Rattlesnake, a second is more progressive than any occurring in the other Pliocene horizons. It is on the occurrence of a progressive stage of *Pliohippus* and the absence of primitive species of *Pliohippus* that Frick determines the Eden fauna as of late Pliocene age, although not so advanced as the Blanco.

Fig. 472. Map showing the position of the San Timoteo and Eden deposits in geographic relation to the Etchegoin, Ricardo, Chanac, Pinole Tuff-Orinda, Thousand Creek, Rattlesnake, Snake Creek, Republican River Pliocene. These are the more important of the Pliocene fossil mammal deposits lying west of the Mississippi River. After Frick, 1921, p. 280, fig. 1a.

7. San Timoteo and Eden horizon of California.
6. Ricardo horizon of California.
5. Chanac horizon of California.
4. Etchegoin horizon of California.
3. Pinole Tuff-Orinda horizon of California.
2. Thousand Creek horizon of Nevada.
1. Rattlesnake horizon of Oregon.
11. Blanco horizon of Texas.
10. Republican River horizon of northern Kansas.
9. Loup River of central Nebraska.
8. Snake Creek of western Nebraska.

Several horizons west of the Mississippi.

FRICK'S DESCRIPTION OF 1926

In 1926 (pp. 169–176) Frick redescribed "The Depressed-Beaked Mastodon of the Eden Lower Pliocene. California" as *?Rhynchotherium (Dibelodon) edensis*, materials originally described by him in 1921 as *Trilophodon (Tetrabelodon) shepardi edensis*. In this paper (1926, p. 171) he continued to regard as a paratype of *?R. (Dibelodon) edense* "Portions of premaxilla containing complete upper tusks possibly of the same individual as type specimen, Univ. Cal. 24047" (Figs. 471 and 523 of the present Memoir), not accepting Osborn's transfer to *Dibelodon* [=*Cordillerion*] of these premaxillary and tusk specimens. Accordingly in his paper of 1926 this species of *?R. (Dibelodon) edense* is fully redescribed and redefined (p. 171) as including the premaxillæ and upper tusks (Figs. 471 and 523 of the present Memoir), which Osborn now renames *Cordillerion edensis*. Frick (p. 172) rightly included within *?R. (Dibelodon) edense* the immature mandible and dentition (Amer. Mus. 18216B) and maxilla (Amer. Mus. 18218) which Osborn (1929.797, pp. 6, 7) described as *Rhynchotherium paredensis*, a species which now proves to be synonymous with *Rhynchotherium shepardi edense* Frick, 1921.

SUMMARY OF RHYNCHOTHERIUM SHEPARDI EDENSE MATERIALS INCLUDING OSBORN'S TYPES OF CORDILLERION EDENSIS (UNIV. CALIF. 24047) AND RHYNCHOTHERIUM PAREDENSIS (AMER. MUS. 18216B, 18218)

Total Materials.—Frick (1926) has recently enumerated the entire material, including parts of approximately nineteen individuals, in the American Museum and University of California collections from the Eden quarry, all of which he regards as referable to the species named by him (*op. cit.*, p. 171) "(?) *R. (Dibelodon) edensis.*"

Type.—Maxilla with r.M² (broken) and M³ of both sides; portions of premaxilla and superior tusks presumably of the same individual (then considered as a paratype, see below). Figured by Frick, 1921, fig. 160 and Pl. L—Fig. 470 [= *Rhynchotherium shepardi edense*] and Fig. 471 [=*Cordillerion edensis*] of the present Memoir; Univ. Calif. 23501 and 24047.

Paratypes.—Portions of premaxilla and superior tusks (see above) supplemented by subsequent excavation of distal portions of tusks and balance of premaxilla (Univ. Calif. 24047), possibly of same individual as type specimen (Univ. Calif. 23501). Figured by Frick, 1921, Pl. L, figs. 1 and 2—Fig. 471 of present Memoir; Osborn, 1922.564, figs. A1, A2—Fig. 523 of present Memoir).

Two superior molars of right and left sides respectively (Univ. Calif. 23503 and 23504). Figured by Frick, 1921, figs. 162 and 164—Fig. 470 of present Memoir.

Inferior molar (Univ. Calif. 23502). Figured by Frick, 1921, fig. 165—Fig. 470 of present Memoir.

Portion of superior molar, worn (Univ. Calif. 23505). Figured by Frick, 1921, fig. 161—Fig. 470 of present Memoir.

Portions of three worn molars (Univ. Calif. 24049 and 23507).

Milk molar (Univ. Calif. 23506). Figured by Frick, 1921, fig. 163—Fig. 470 of present Memoir.

Distal portion of small tusk (Univ. Calif. 24050). Figured by Frick, 1921, fig. 159.

Skeletal fragments.

Referred New Materials, Type Locality

Mature Specimens:

M_3 left, much worn (Amer. Mus. 18219). Figured by Frick, 1926, fig. 21B—Fig. 473 of present Memoir.

M³ left, unworn (Amer. Mus. 18219D). Figured by Frick, 1926, figs. 21A and C—Fig. 473 of present Memoir.

M³ right, much worn (broken), similar to above (Amer. Mus. 18219E).

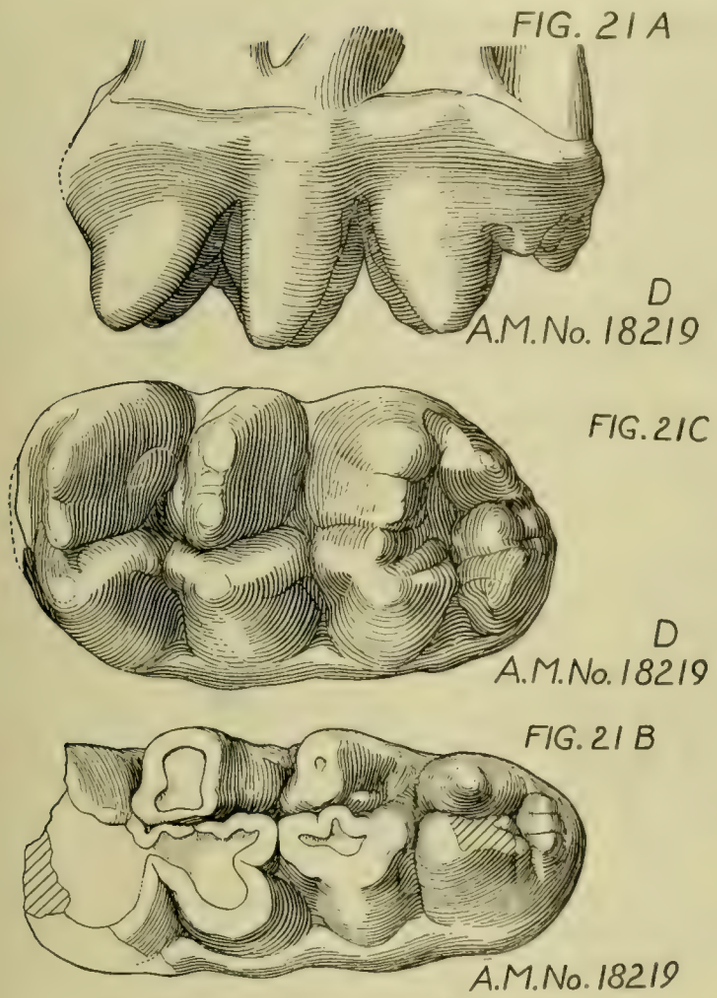


Fig. 473. Referred superior, l.M^3, and inferior, l.M_3, grinders of *Rhynchotherium shepardi edense*, Pliocene, Eden formation, California. After Frick, 1926, pp. 144, 145, one-half natural size.

(Figs. 21A, C) Amer. Mus. 18219D. Third superior molar of the left side, l.M^3.

(Fig. 21B) Amer. Mus. 18219. Third inferior molar of the left side, l.M_3.

Portion of right maxilla with large M^3 (broken) and fragment of M^2 (Amer. Mus. 18219A).

Portion of maxillary palate with M^3, and fragment of M^2 of right side (Amer. Mus. 18219C).

Fragment of left (?) maxilla with relatively small M^3 (heel broken) and fragment of M^2 (Amer. Mus. 18219B).

Portion of left maxilla with parts of Dp^4, M^1 (Amer. Mus. 18219F).

Intermediate left superior molar, slightly worn (Amer. Mus. 18219G).

Three third milk molars greatly worn, exhibiting a considerable size variation and a fourth milk molar greatly worn (Amer. Mus. 18223A-C).

Distal portion of several tusks (Amer. Mus. 18221).

Fragment of inferior tusk with enamel on two sides (Amer. Mus. 18221Z).

Ulna and partial radius of moderately long and heavy proportions (Amer. Mus. 18350 [18220]).

Limb and vertebra portions and fragments (Amer. Mus. 18222).

Immature Specimens [described by Osborn, 1929.797, as the type of *Rhynchotherium paredensis* = synonym of *R. shepardi edense*]:

Mandible consisting of a left ramus with Dp_2, Dp_3, Dp_4, and M_1 in germ; and right ramus with alveolus Dp_2, Dp_3, and Dp_4 erupting (Amer. Mus. 18216B). Figured by Frick, 1926, figs. 2, 8, and 25.

Fragment of mandible with Dp_3 left (only slightly worn) and portion of alveolus Dp_2 (Amer. Mus. 18216A). Figured by Frick, 1926, figs. 3 and 9.

Left maxilla with Dp^2, Dp^3, and Dp^4 (broken) erupting, and associated Dp^3 right (posterior third missing); specimen showing infra-orbital foramen above anterior edge Dp^2, tusk alveolus, and portion of maxillary palate, representing a somewhat younger individual than the mandibular specimen, Amer. Mus. 18218 (tooth series figured by Frick, 1926, fig. 18).

Specific Characters based upon above Material.—(Frick, 1926, p. 172): "Characters.—Last molars with three main transverse crests and posterior heel, the heel being small and tubercular in m^3, and more prominent and crest-like in m_3 (referred specimen); intermediate teeth with three crests; transverse valleys broad and well defined, though blocked at mid-base; inner lobes of upper and outer lobes of lower teeth, in worn stage, exhibiting trefoils; upper molars broad, inner borders strongly convex; lower molars relatively long and narrow, m_3 inner border slightly concave and outer border convex; tubercular ridges tall and directed forward in both jaws; palate apparently narrow. Upper tusks (possibly of same individual as type specimen) widely divergent and each provided with an enamel band, which by an inward rotation of the tusk axis is carried from the outer border at the base to the inner border at the tip. Mandible (as seen in immature referred specimen): ramus at mental foramen deep, symphyseal region narrow, somewhat elongate, and bent strongly downward; inferior tusks present, laterally compressed and downwardly directed, tips curving slightly forward and upward; permanent premolars apparently never developed, anterior series consisting of dp_2–dp_4; unerupted teeth tending to be minutely tuberculo-serrate. Upper anterior series (as seen in very slightly worn teeth of the referred immature maxillary specimen) consists of dp^2 (somewhat triangular and weakly bilobed), p^3 (tending to be trilobed), and dp^4."

Juvenile Specimens of R. shepardi edense

The type of *Rhynchotherium paredensis* (Fig. 474), based upon an immature individual (Amer. Mus. 18216B) discovered in the Eden quarry with the type of *Rhynchotherium shepardi edense* (Fig. 470), was rightly regarded by Frick as possibly an immature individual of the animal previously described by him as *Trilophodon shepardi edensis* (= *R. shepardi edense* of the present Memoir), although subsequently (1926) he referred all the Eden material (mature and immature specimens) to the genus *Rhynchotherium*. Osborn erroneously made this the type of *Rhynchotherium paredensis* which proves to be a synonym of *R. shepardi edense*.

This immature material (Amer. Mus. 18216B, 18218) is now assigned the name *Rhynchotherium shepardi edense*, readily distinguished by the upturned inferior tusks with broad enamel band, as shown in the new figure 474. This *Rhynchotherium* resemblance was observed by Frick (1926, p. 171) as follows: . . . "the laterally compressed and downwardly directed tusks of the immature mandible are highly suggestive of the Cope Blanco mandible, the upper tusks of which are unknown. I, therefore, tentatively refer the Eden material to *Rhynchotherium* Falconer (genotypic species, *R. tlascalæ* Osborn), to which genus Professor Osborn has now transferred the Blanco specimen [= *Rhynchotherium falconeri*]."

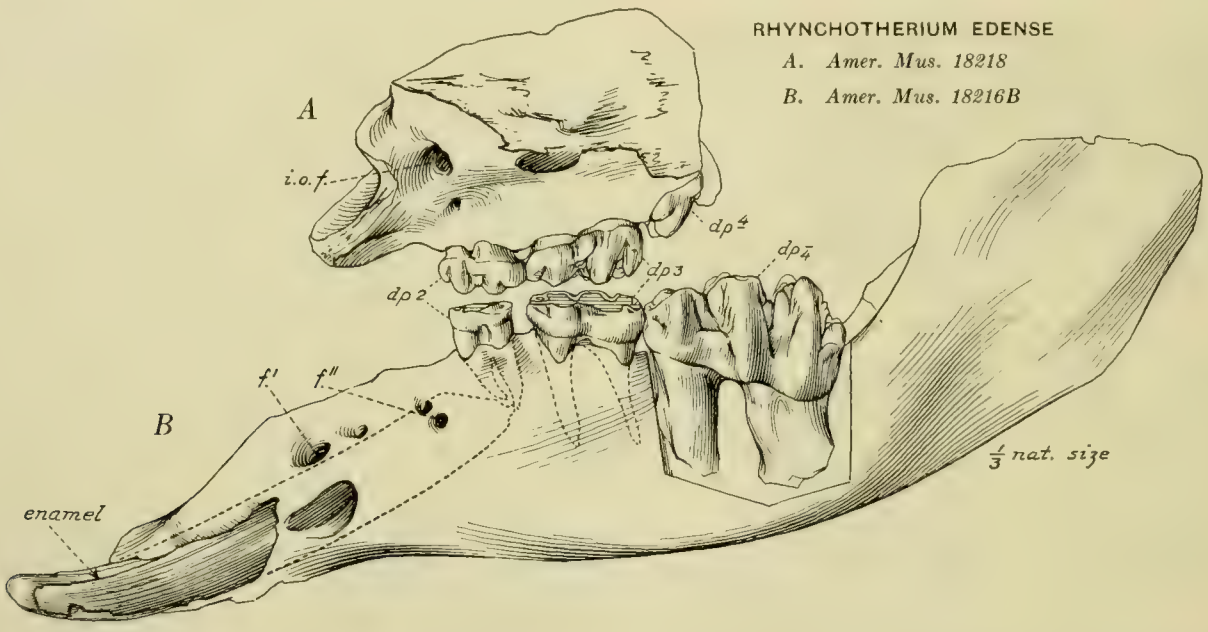


Fig. 474. Immature *Rhynchotherium shepardi edense* (Amer. Mus. 18216B, jaw, Amer. Mus. 18218, maxilla), as refigured for the present Memoir. Compare Osborn, 1929.797, fig. 8, and Frick, 1926, figs. 2, 3, 8, 9, and 18. Figured by Osborn in 1929 as *Rhynchotherium paredensis*.

History (Frick, 1926, p. 169).—In 1926 (p. 169) Frick described the "Depressed-Beaked Mastodon of the Eden Lower Pliocene. California, (?) *Rhynchotherium* (*Dibelodon*) *edensis* Frick," referring principally to "immature specimens" (Amer. Mus. 18216B and 18218), but with which he included other described and undescribed adult material now referred by the present author to *Cordillerion edensis* in Chapter XII below on the Notorostrinæ. The immature jaw and left maxilla we may consider as a true Rhynchorostrine and it is here carefully refigured in the new illustration (Fig. 474).

(?) *Rhynchotherium paredensis* Osborn, 1929. "New Eurasiatic and American Proboscideans," Amer. Mus. Novitates, No. 393, Dec. 24, pp. 6–8. Type.—Immature mandible containing l.Dp_2, r. and l.Dp_3, Dp_4, and both tusks (Amer. Mus. 18216B), also a left maxilla (Amer. Mus. 18218) containing l.Dp^2, Dp^3, Dp^4—probably belonging to one individual owing to close similarity in age, size, and eruption of the teeth. Frick collection, Mr. Joseph Rak collector, winter of 1916–1917. Horizon and Locality.—Upper Pliocene, Mt. Eden Hot Springs, San Bernardino County, southern California. Type Figure.—*Op. cit.*, Osborn, 1929.797, fig. 8, p. 7 (cf. Frick, 1926, figs. 2, 3, 8, 9; referred maxilla, fig. 18).

The first description of this unique material from Eden is that of Frick (1926, pp. 170, 171), who concludes as follows (p. 171): "I, therefore, tentatively refer the Eden material to *Rhynchotherium* Falconer (genotypic species, *R. tlascalæ* Osborn), to which genus Professor Osborn has now transferred the Blanco specimen [i.e., *Rhynchotherium falconeri* type, Amer. Mus. Cope Coll. 8532]." There can be little doubt that the three immature specimens (Amer. Mus. 18216B, 18216A, and 18218) belong to the genus *Rhynchotherium*. To Frick's designations and descriptions (*op. cit.*, pp. 171, 172) of these "immature specimens" and to his figures 2, 3, 8, 9, and 18, we may now add the following characterization.

Measurements (Osborn) of Superior and Inferior Molars

Left Lower Series	Dp_2	Dp_3	Dp_4
Anteroposterior	25	50	90
Transverse	17	37	51+
Right Lower Series			
Anteroposterior		50	86
Transverse		41	57
Left Upper Series	Dp^2	Dp^3	Dp^4
Anteroposterior	36	47	(half crown)
Transverse	27	41	51

Type Description (compare Osborn, 1929.797).—Immature mandible terminating in a downturned symphyseal region, above which is a broad, concave, troughlike superior surface and beneath which are two closely appressed lower incisive teeth, the

vertical diameter greatly exceeding the transverse; near the root of $l.I_2$ is a very large foramen on the outside of the ramus (Fig. 474); the right lower tusk, $r.I_2$, is closely compressed vertically; the lower deciduous premolars Dp_3, Dp_4, are trilophodont or three crested, with rudimentary conelets partly blocking the valleys on the external side, while in the corresponding superior tooth, (39) of the species *Cuvieronius platensis* agrees rather closely with that of *Cordillerion andium* (index 44) and with that of *Rhynchotherium shepardi edense* (index 42). While agreeing in their long, narrow proportions, other characters (foldings or plications, double trefoils, thinness of the enamel) may readily distinguish these mastodonts from *Rhynchotherium*.

COMPARATIVE PROPORTIONS OF RHYNCHOTHERIUM, CORDILLERION, AND CUVIERONIUS GRINDERS

(See comparison of *Rhynchotherium* and *Serridentinus*, p. 483 above)

	ap.	tr.	height	I.	
R.M_3 (Leidy, 1873, p. 235, cast Amer. Mus. 12388—Fig. 454)	162.5	72.5	45e	45	*Rhynchotherium shepardi* ref.
L.M_3 (Frick Coll., Amer. Mus. 18219—Fig. 473)	160.5	68	50e	42	*Rhynchotherium shepardi edense* ref.
R.M^3 (Frick Coll., Amer. Mus. 18219A)	161e	91	72e	56	" " " "
L.M^3 (Frick Coll., Amer. Mus. 18219B)	150	82.5	61	55	" " " "
R.M^3 (Frick Coll., Amer. Mus. 18219C)	162	87.5	55e	54	" " " "
L.M^3 (Frick Coll., Amer. Mus. 18219D—Fig. 473)	151	84	63	55	" " " "
R.M^3 (Frick Coll., Amer. Mus. 18219E)	155	83	..	53	" " " "
L.M^3 (Univ. Cal. 23501—Fig. 470)	150	80	60	53	*Rhynchotherium shepardi edense* type
L.M^2 (Frick Coll., Amer. Mus. 18219F)	112e	80	58	71e	*Rhynchotherium shepardi edense* ref.
L.M^2 (Frick Coll., Amer. Mus. 18219G)	117	73	61	62	" " " "
R.M^2 (Univ. Cal. 23503—Fig. 470)	128	84	..	65	" " " "
L.M_2 (Univ. Cal. 23502—Fig. 470)	130	73e	50	56	" " " "
L.M_3 (Quito Mus., cast Frick Coll.)	182	81	..	44	*Cordillerion andium* ref.
R.M_3 (Frick Coll. 9–1931, Ecuador)	231.5	96	75	41	*Cuvieronius humboldtii* ref.
R.M_3 (Amer. Mus. Cope Coll. 11192—Fig. 554)	224	89	..	39	" *platensis* "
R.M_2 (Frick Coll. 9–1931)	135	88	..	65	" *humboldtii* "
R.M_2 (Amer. Mus. Cope Coll. 11192—Fig. 554)	138e	94	..	68	" *platensis* "

namely, $l.Dp^4$, the rudimentary conelets block the valleys on the internal side, as in *Serridentinus;* the crowns are covered with irregular tubercles or are 'chœrodont' in type, as in all deciduous premolars of the Trilophodonts.

RHYNCHOTHERIUM GRINDERS.—*Rhynchotherium* grinders may now be readily distinguished from those of contemporary mastodonts (*Trilophodon* Falc., *Eubelodon* Barb., *Cordillerion* Osb., *Cuvieronius* Osb., and *Serridentinus* Osb.) by: (1) Very thick enamel with absence of secondary foldings or plications, (2) presence of thick-enamelled trefoils, internal above, external below, (3) 3½ ridge-crests in third superior molars, (4) 4⅓–5 ridge-crests in third inferior molars, (5) relatively low, obtusely rounded lophs, persistently short crowned or brachyodont, (6) relatively long and narrow third inferior grinding teeth, height 45–63 mm., breadth–length index 42–45. (7) These blunt, non-progressive, thick-enamelled grinders are correlated with the trituration of coarse herbage and the downturned inferior incisive tusks for the uprooting of trees.

THIRD INFERIOR MOLARS, M_3	ap.	tr.	I.
Rhynchotherium shepardi edense	160.5	68	42
Cordillerion andium	182	81	44
Cuvieronius platensis	224	89	39
Trilophodon (Megabelodon) lulli	222	89	40
Ocalientinus (Ser.) floridanus	226	85	38

The relative size of the grinding teeth of *Rhynchotherium*, *Cordillerion*, and *Cuvieronius* is displayed in the comparative table above. In the mastodonts cited herewith the third inferior molars are relatively long and narrow. The breadth-length (tr.×ap.) index

(?) Rhynchotherium francisi Hay, 1926

Figure 475

Brazos River, Pittbridge, Burleson County, Texas. (?) Pliocene.
Of uncertain geologic age and systematic reference.

Mammut francisi Hay, 1926. "Two New Pleistocene Mastodons," Journ. Washington Acad. Sci., Vol. XVI, No. 2, January 19, 1926, pp. 35–39. TYPE.—A third superior molar of the right side, $r.M^3$. HORIZON AND LOCALITY.—"This tooth was found in Brazos River, at Pittbridge, Burleson County," Texas. TYPE FIGURE.—*Op. cit.*, p. 36, fig. 3, p. 37, fig. 4.

TYPE DESCRIPTION.—(Hay, 1926, pp. 35–39): "It is the upper right third molar and had not yet begun to wear. One striking feature is the great width of the tooth. It is possible that this is abnormal, but there is no indication of it, and a tooth of *M. americanum* at hand is as wide at the first two crests, but does not diminish so much in width at the third and fourth crests. The total length is 147 mm.; the width taken at the first and second cross-crests is 100 mm. At the third and fourth cross-crests the width is respectively 86 mm. and 70 mm. It may be said that there is a small fifth crest, only the pretrite portion of which is developed. Behind this is what may be regarded as a small talon. The buccal border of the tooth is straight; the lingual border, strongly convex. One might expect the reverse condition. . . . Believing that the tooth here described from Pittbridge represents a species of *Mammut* not hitherto recorded and wishing to honor the finder [Dr. Mark Francis], the writer proposes to call it *Mammut francisi*."

Osborn, 1931: This type, $r.M^3$, 147×100 mm., ridge-crests 4½, extremely broad anteriorly, narrowing rapidly posteriorly

cement in the valleys, with obtuse trefoils (not observed by Hay) on first, second, third, and fourth internal lophs, without the distinct transverse lobation of *Mastodon*, with nearly plain external surface, and with strongly convex and bulging internal surface, is comparable rather to *Rhynchotherium brevidens* (Figs. 456, 458) and *R. anguirivale* (Fig. 466) than to *Mastodon americanus* with which it was compared by Hay (January, 1926, pp. 35–39). The comparative measurements and indices are as follows:

TYPE FIGURE OF RHYNCHOTHERIUM FRANCISI

Fig. 475. Type figure of *Mammut francisi* Hay, 1926, figs. 3 and 4, one-half natural size, found in Brazos River, at Pittbridge, Burleson County, Texas, by Dr. Mark Francis, to whom the species was dedicated. A third superior molar of the right side, r.M^3, crown and external views. Compare r.M^3 of *R. francisi* type with l.M^3 of *R. shepardi edense* type (Fig. 470).

COMPARATIVE PROPORTIONS OF MASTODON AND RHYNCHOTHERIUM GRINDERS

Third Superior Molar, M^3	ap.	tr.	I.
Mastodon americanus (Nat. Mus. 335)	175	102	58
Rhynchotherium shepardi edense (Univ. Cal. 23501)	150	80	53
Rhynchotherium anguirivale (Amer. Mus. 19248c)	163e	83	51e
Rhynchotherium brevidens (Amer. Mus. Cope Coll. 8137)	154	98	64
Rhynchotherium francisi (Francis Coll.)	147	100	68

It differs from species of *Rhynchotherium*, in which the superior molars are known (*R. brevidens*, *R. anguirivale*, *R. falconeri*), in the (a) flattened internal and broadly convex external surfaces, (b) in the presence of the more strongly developed fourth ridge-crest or tetartoloph, and in the greater prominence of the talon or pentaloph. It differs still more widely from *Mastodon americanus* in the (a) triangular form of M^3, (b) in the absence of the transverse lophoid structure of the ridge-crests, (c) in the presence of a deep median valley between the external and internal cones, with intermediate conules (?), (d) in the presence of more prominent internal trefoils.

Subject to further knowledge, *Mammut francisi* Hay, 1926, may be regarded as a progressive but somewhat aberrant Rhynchorostrine. An alternative reference of this aberrant tooth would be to the genus *Cordillerion* with which the present molar agrees in the following characters: (a) 4½ ridge-crests, (b) flat external and strongly convex internal surface of M^3. It differs, however, from *Cordillerion* (Fig. 488) in (a) the much greater breadth of the crown, (b) the strong fore-and-aft compression, (c) the less pronounced development of the internal trefoils.

7. MIO-PLIOCENE RHYNCHOTHERIUM OF INDIA

Rhynchotherium chinjiense Osborn, 1929

Figures 476 and 481

From two miles west of Chinji Bungalow, India. Mio-Pliocene.

The last of the Rhynchorostrine specimens to be described is the left ramus of a lower jaw (Amer. Mus. 19415), which is provisionally placed with *Rhynchotherium* although the fractured rostrum leaves the reference somewhat uncertain; the alveolar section of the left lower incisive tusk, l.I_2, resembles that of *Rhynchotherium*, as the *vertical* exceeds the transverse diameter; the presence or absence of a distinctive lateral enamel band cannot be determined; the brachyodont third lower molar, l.M_3, corresponds with that of *Rhynchotherium shepardi;* the horizon is the Lower Siwaliks of India, 600 feet above the base, found two miles west of Chinji Bungalow. As shown in figure 476 the size agrees with that of the type of *R. browni* (Fig. 467) from the Upper Pliocene of Mexico. The original description of this species is in general as follows:

Rhynchotherium chinjiensis Osborn, 1929. "New Eurasiatic and American Proboscideans," Amer. Mus. Novitates, No. 393, pp. 6 and 7. TYPE.—Amer. Mus. 19415. Left ramus with warped alveolus of left inferior incisor, l.I_2; also l.M_2, M_3, *in situ*.

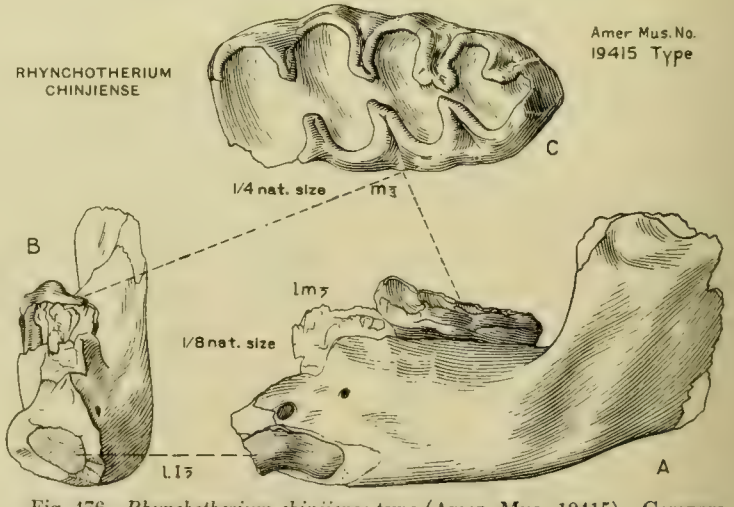


Fig. 476. *Rhynchotherium chinjiense* type (Amer. Mus. 19415). Compare Osborn 1929.797, p. 8, fig. 9). A, Outer aspect of left type ramus showing the warped alveolus of the left inferior incisor, l.I_2, broken crown of l.M_2, and four crested crown of l.M_3. One-eighth natural size. B, Anterior view of type ramus showing warped alveolus of second inferior incisor filled with sand and matrix. One-eighth natural size. C, Crown view of four crested l.M_3. One-fourth natural size. Observe the thickened enamel.

LOCALITY.—Two miles west of Chinji Bungalow, India. HORIZON.—Collected in 1922 by Barnum Brown 600 feet above the base of the Lower Siwaliks. Mio-Pliocene. TYPE FIGURE.—*Op. cit.*, Osborn, 1929.797, p. 8, fig. 9.

SPECIFIC CHARACTERS.—Mandibular ramus deep, abbreviate, rostrum apparently downturned, containing alveolus of a single flattened incisor, warped in the type. Third inferior molar brachyodont, four crested, with thick enamel, ap. 200 mm., tr. 92 mm., thus resembling *Rhynchotherium* [*Blickotherium*] *euhypodon;* 4½ ridge-crests, no indication of trefoils on the deeply worn crown, trefoils are indicated in corresponding l.M$_3$ of *R.* [*B.*] *euhypodon* (Fig. 462 A4).

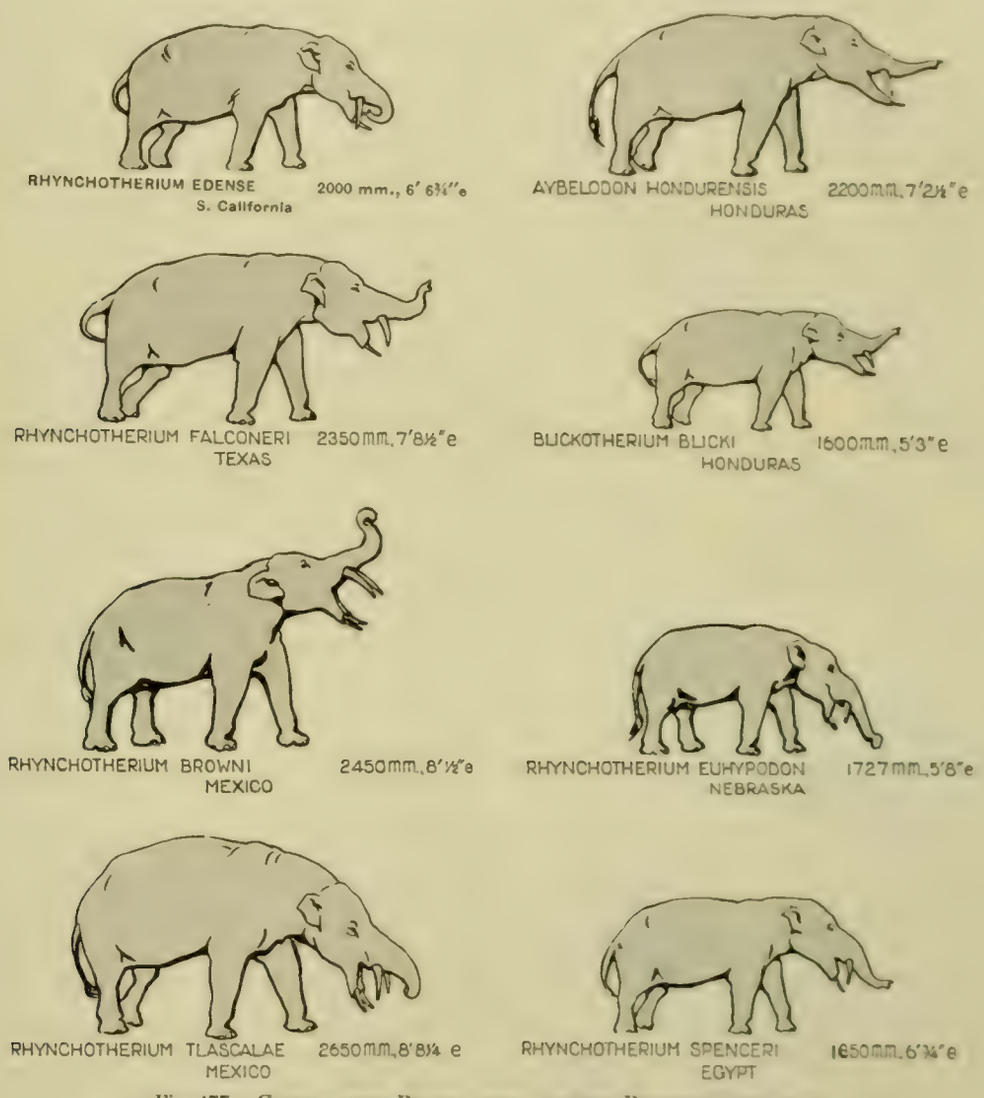


Fig. 477. COMPARATIVE RESTORATIONS OF THE RHYNCHOROSTRINES
BY MARGRET FLINSCH (1932), UNDER THE DIRECTION OF HENRY FAIRFIELD OSBORN
One-hundredth natural size

The absolute scale of these Rhynchorostrines is determined by the only limb skeleton known at present, namely, that of *Rhynchotherium shepardi edense* of southern California described on page 496 above, which establishes a shoulder height of 6 ft. 6¾ in. (2000 mm.). From the jaw of this animal a relative scale is established by a careful comparison with the jaw lengths and lengths of the third inferior molar teeth of the other species. In descending order of height, the estimated measurements are as follows:

R. tlascalæ, Mexico	2650 mm., 8 ft. 8¼ in.	*R. edense*, So. California	2000 mm., 6 ft. 6¾ in.
R. browni, Mexico	2450 mm., 8 ft. ½ in.	*R. spenceri*, Egypt	1850 mm., 6 ft. ¾ in.
R. falconeri, Texas	2350 mm., 7 ft. 8½ in.	*R.* [*Blickotherium*] *euhypodon*, Nebraska	1727 mm., 5 ft. 8 in.
Aybelodon hondurensis, Honduras	2200 mm., 7 ft. 2½ in.	*Blickotherium blicki*, Honduras	1600 mm., 5 ft. 3 in.

No complete cranium is known, therefore the facial, as well as the bodily, profile is conjectural. For skeletal characters and measurements the reader is referred to pages 507 and 508 of the present Memoir.

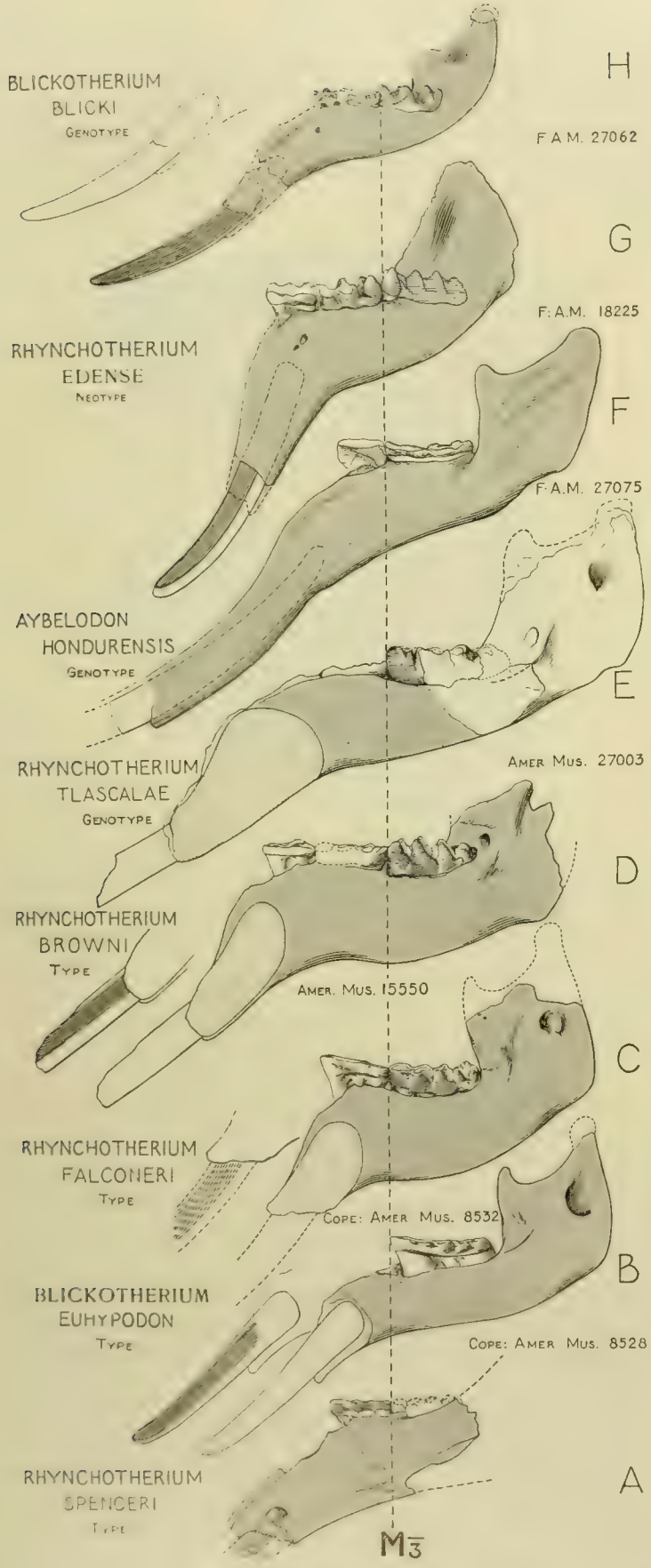


Fig. 478. Rhynchorostrine Mandibles and Tusks, North Africa to Honduras

All figures one-twelfth natural size. Compare figures 479–482

H, Genotype. *Blickotherium blicki* Frick, 1933. Honduras, Central America. Right mandibular ramus (reversed in this drawing), after Frick, 1933, fig. 4, F:A.M. 27062 (M_1 restored from left side).

Inferior incisors upcurved, strongly compressed laterally, broad external enamel band. Third inferior molar, r.M_3, with four ridge-crests, tetartolophid rudimentary, ap. 119 mm. × tr. 61 mm., index 51; M_2 trilophoid, with three ridge-crests and basal cone, ap. 86 mm., tr. 52 mm., index 60; M_1 bilophoid, anterior ridge-crest rudimentary. Symphysis laterally compressed, downwardly curved, embracing upcurved lower incisors. Compare figure 479.

G, Neotype, 1933, *Rhynchotherium edense* Frick, 1926. East of Mt. Eden, southern California, Eden horizon. Immature mandible with four ridge-crested M_3 buried in jaw, after Frick, 1933, fig. 1, F:A.M. 18225. Close to *R. falconeri* (C).

Inferior incisors suboval in vertical section, enamel band latero-superior, upcurved, embedded in sharply depressed symphysis. M_1 partly trilophoid, ap. 104e mm., tr. 66 mm., index 63e; M_2 fully trilophoid, ap. 128 mm., tr. 82 mm., index 64; M_3 tetralophoid, with tetartolophid more prominent than in *Blickotherium blicki*, ap. 176 mm., tr. 80 mm. index 45. Mandible relatively short, angle to symphysis, ap. 670 mm.

F, Genotype, *Aybelodon hondurensis* Frick, 1933. Late Tertiary of Honduras, Central America, after Frick, 1933, fig. 5, F:A.M. 27075, mandible reversed in this drawing.

Lower incisors entirely without enamel, suboval in section, slightly compressed laterally, with symphysis extremely elongate, laterally and vertically compressed, embedding the long, upcurved, enamel-less lower tusks; hence probably of generic value as *Aybelodon*. Grinders with thick enamel; M_2 greatly worn, reduced in size, ap. 110e mm., tr. 60 mm., index 54e, probably trilophoid; M_3 fully tetralophoid, with four ridge-crests and rudimentary single-coned pentalophid, ap. 173 mm., tr. 76 mm., index 44.

E, Genotype, *Rhynchotherium tlascalæ* Osborn, 1918. Near Tlascala, Valley of Mexico. Mandible of relatively large size, total length of ramus, condyle to end of symphysis, 1070 mm. After genotype cast (Amer. Mus. 27003), compare figure 448. Important as subject of Falconer's original type description of the genus *Rhynchotherium*.

Mandible elongate and shallow, symphysis very large, less strongly decurved than in any other known species (A–H). Incisors round with flattened inner section; apparently, from cast, with broad external enamel band. M_3 very large, ap. 180e mm., tr. 99 mm., index 55e, with four ridge-crests, tetartolophid partly embedded in jaw. Diameter of tusk 65 mm.

D, Type, *Rhynchotherium browni* Osborn, 1933 (Amer. Mus. 15550). San José de Pimas, Sonora, Mexico. Formerly (1921) erroneously described by Osborn as the neotype of *R. tlascalæ*, now seen to be more primitive, with longer jaw than *R. falconeri* (C); close to *R. edense* (G).

Mandible relatively elongate as compared with *Rhynchotherium falconeri* (C), symphysis obliquely depressed, relatively short; incisors laterally compressed or deeply oval, with broad external enamel band. M_1 subtrilophoid, with rudimentary tritolophid, ap. 98 mm , tr. 67 mm., index 68; M_2 fully trilophoid, with rudimentary basal cone, ap. 136e mm., tr. 100 mm., index 74e; M_3 tetralophoid, with narrow two-coned tetartolophid, ap. 176 mm., tr. 96 mm., index 55. Ramus stout.

C, Type, *Rhynchotherium falconeri* Osborn, 1923. Blanco formation, Llano Estacado, Texas, Upper Pliocene. Amer. Mus. Cope Coll. 8532. Originally referred by Cope to "*Tetrabelodon shepardii*, Leidy."

Mandible relatively short and broad, angle to symphysis 630 mm., coronoid condylar region elevated, ramus deep, symphysis obliquely depressed downwardly, less vertical than in *Rhynchotherium edense* (G). M_1 shed; M_2 trilophoid, much worn, ap. 133e mm., tr. 77 mm., index 58e; M_3 tetralophoid, with well-developed tetartolophid and rudimentary biconed pentalophid, ap. 173 mm., tr. 80 mm., index 46.

B, Type, *Rhynchotherium* [*Blickotherium*] *euhypodon* Cope, 1884. Driftwood Creek, Hitchcock County, Nebraska. Amer. Mus. Cope Coll. 8528.

Mandible relatively slender and shallow; coronoid condylar region also slender; symphysis moderately downcurved; relatively short incisive tusks, with broad enamel band. M_1, M_2 entirely shed, M_3 relatively long and narrow, ap. 182 mm., tr. 78 mm., index 43, with four prominent ridge-crests and biconed pentalophid.

A, Type, *Rhynchotherium spenceri* Fourtau, 1918. From desert of Moghara, Egypt, After Fourtau, 1918, figs. 60, 61.

Mandible downcurved, very large anterior foramen. M_2, ap. 110e mm.

8. NEW HONDURAS PHYLUM: BLICKOTHERIUM AND AYBELODON, DISCOVERED BY BLICK IN 1929, DESCRIBED BY FRICK IN 1933

It has taken nearly eighty years of ardent exploration by the Cope, Osborn, and Frick parties to amplify our knowledge of these rare and probably forest-living animals. This knowledge is graphically set forth in figure 478, with its full explanatory legend, which constitutes the frontispiece of the present Section 8.

As summarized above, the text of the present chapter was completed (pp. 475–503) and put into page proof in the year 1929; since then four very important advances in our knowledge of the Rhynchorostrinæ have been made. *First*, by the rediscovery of the original genotype cast of *Rhynchotherium* Falconer. *Second*, by Frick's amplification of our knowledge of *Rhynchotherium edense* of California. *Third* and *fourth*, by Frick's unexpected discovery of two new generic and specific types in Honduras, namely, *Blickotherium blicki* and *Aybelodon hondurensis*. Consequently the wide adaptive radiation as well as the habits and the phylogenetic succession of the Rhynchorostrines are newly conceived and established. This is a most welcome and surprising confirmation of Hugh Falconer's adumbration in the year 1856 of the existence in Mexico of an entirely distinct kind of lower jaw of what are now known as the Beak-jawed Mastodonts or Rhynchorostrines.

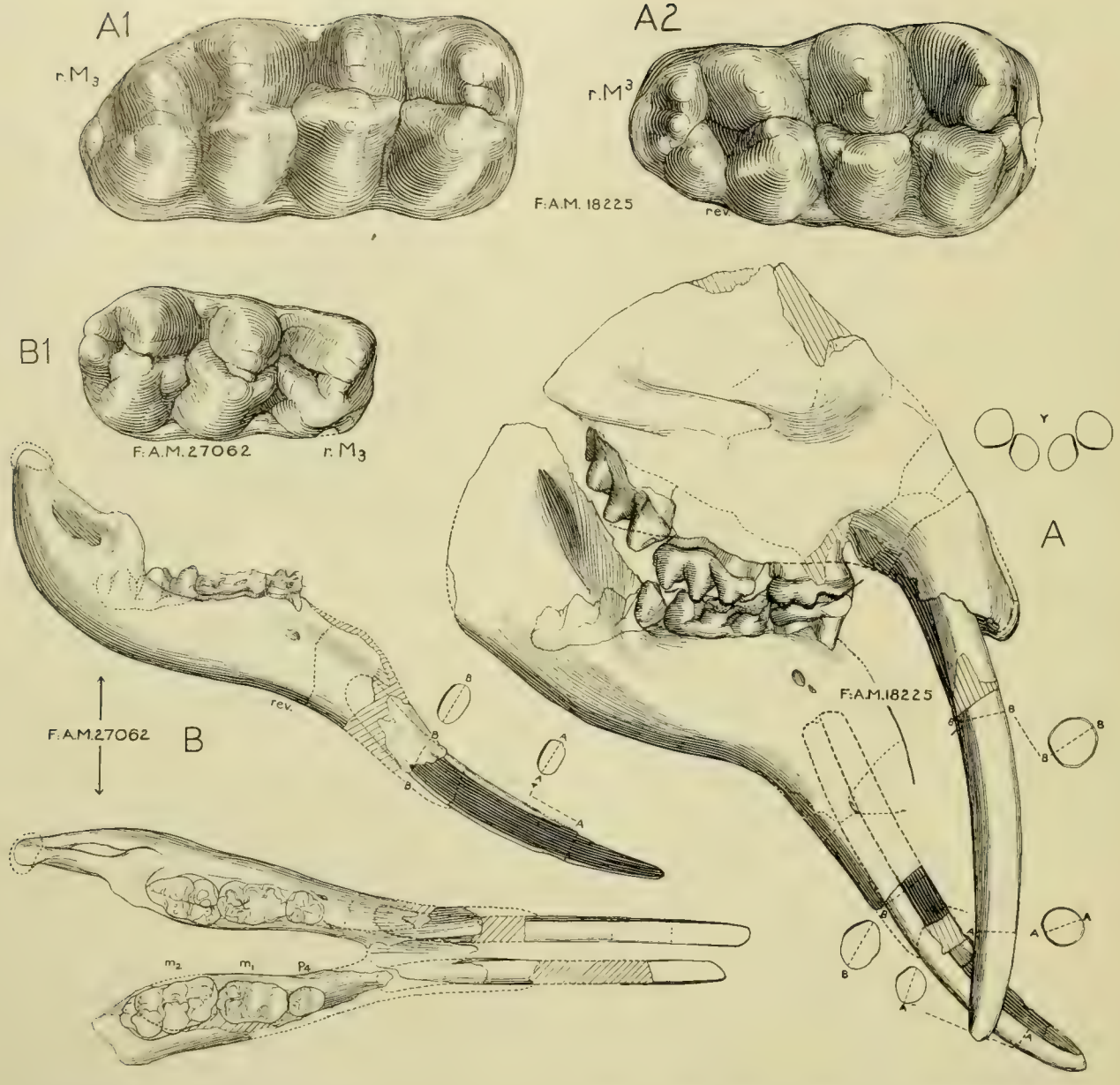
More in detail, these four significant advances in our knowledge of the Rhynchorostrines since 1929 are as follows:

First, in 1931, the rediscovery in the Museum of Geneva of the cast (Fig. 478E) of the genotypic jaw of *Rhynchotherium* Falconer enables us fully to characterize the genotypic species *Rhynchotherium tlascalæ* by the duplicate cast in the American Museum (Amer. Mus. 27003). The erroneously selected (Osborn, 1923) neotype specimen (Fig. 478D) of *R. tlascalæ* is obviously quite different from the genotype jaw of *R. tlascalæ* (E) and now proves to be much more similar to the type jaw (C) of *R. falconeri* Osb., as clearly shown in the comparative figure (D, C); although similar, this jaw (D) is seen to be more elongate and decidedly more primitive than the type (C) of *R. falconeri;* it is accordingly made the type of a new species *R. browni*, named in honor of Barnum Brown who discovered this mandible in Mexico in the year 1911.

Second, in 1932, the discovery by Frick's parties in the Eden horizon of California of several specimens of *Rhynchotherium shepardi edense* Frick, including the anterior portion of the skull of the type, also the relatively complete neotype cranium and jaw (Fig. 478G) revealing a stout, strongly decurved mandible suggestive of that of the type (C) of *R. falconeri* Osb. The surprising adaptations of the mandible, displayed in the contrast between the type of *R. tlascalæ* (E), and the type mandibles of *R. falconeri* (C) and of *R. edense* (G), hardly prepared us for the additional recognition of a third type of long, slender mandible displayed in *R.*[= *Blickotherium*] *cuhypodon* (B) and *Blickotherium blicki* (H).

Third, in 1929, was the most recent discovery in Honduras, as described by Frick in 1933, of the extremely slender mandible, with laterally compressed incisors (Fig. 478H) of *Blickotherium blicki*, similar in its slender proportions to the mandible (B) of *R.* [*B.*] *cuhypodon* Cope but differing in the section of the lower incisors.

Fourth, in 1929, and perhaps most surprising, as described by Frick in 1933, was the discovery of the long, slender type mandible (Fig. 478F) of *Aybelodon hondurensis*, rhynchorostrine in general contour but containing incisors *entirely without enamel*. The profile of this enamel-less type certainly reveals its rhynchorostrine affinity; it places it in a distinct and unique line of succession.



B, BLICKOTHERIUM BLICKI Frick, 1933, Type A, RHYNCHOTHERIUM EDENSE Frick, 1933, Neotype

Fig. 479. Beak-jawed Rhynchorostrines. Rhynchotherium Falc., 1856–1868, Blickotherium Frick, 1933
Frick Collection, California and Honduras

Grinding teeth seven-seventeenths natural size; crania and mandibles about one-tenth natural size. Compare figures 478 and 482.

Note: The three lower grinding teeth of *Blickotherium blicki* (B) are identified by Frick (1933, pp. 527, 529, 650) and by Colbert (in a note) as P_4, M_1, M_2; by the present author (Fig. 478H) as M_1, M_2, M_3.

A, *Rhynchotherium edense* Frick. Neotype immature cranium and mandible (length 1050 mm.), r.M 1- r.M 3 (F:A.M. 18225), Eden horizon, southern California.

A—A and B—B sections of superior and inferior incisive tusks as indicated. Mandible and cranium placed in natural position, with sharp downward deflection of rostrum and vertical position of superior tusks. Compare Frick, 1933, fig. 1.

A1, Neotype third right inferior molar, r.M_3, 4 ridge-crests, ap. 176 mm., tr. 80 mm., index 45.

A2, Neotype third right superior molar, r.M^3, 3–4 ridge-crests, ap. 160 mm., tr. 64 mm., index 40.

B, *Blickotherium blicki* Frick. Genotype mandible (length 625 mm.), M_{1-3} (F:A.M. 27062), from near Tapasuma, Gracios, Honduras, right external and crown aspects, tusks with compressed sections (A—A, B—B). After Frick, 1933, fig. 4.

B1, Same, third right inferior molar, r.M_3, $3\frac{1}{3}$ ridge-crests, ap. 119 mm., tr. 61 mm., index 51.

RHYNCHOROSTRINES (RHYNCHOTHERIUM, BLICKOTHERIUM, AYBELODON) RECENTLY DESCRIBED BY FRICK

See new (1933) comparative mandibular figures (Figs. 478, 482)

Rhynchotherium tlascalæ Osborn, 1918

From Tlascala, Valley of Mexico.

Following the detailed description (pp. 493, 494), the fortunate discovery of Falconer's lost genotype enabled us fully to characterize the original type specimen (Figs. 448, 478E, and 482A) and to distinguish it clearly from Osborn's erroneously referred neotype (Figs. 467 and 478D) described above (p. 494).

As clearly shown in figure 448, in comparison with *Rhynchotherium browni*, and in figure 478E, in comparison with all the other known mandibles, the genotype mandible of *R. tlascalæ* (cast Amer. Mus. 27003) is distinguished by the following characters: (1) Mandible of relatively large size, elongate, and proportionally shallow as compared with *R. browni* (D), or still more with *R. falconeri* (C). It is thus apparently a more primitive stage than either of the above species. The remaining specific characters and measurements are: Symphysis very large, less strongly decurved than in *R. browni* or *R. falconeri;* incisors round with flattened inner section, apparently, from cast, with broad external enamel band; M_3 large, ap. 180e mm., tr. 99 mm., index 55e, with four ridge-crests, tetartolophid partly embedded in jaw; diameter of tusk 65 mm.

Rhynchotherium edense Frick, 1933

Figures 470, 473, 474, 477, 478G, 479, 481, and 482C

From Mt. Eden Hot Springs, San Bernardino County, California. Upper Pliocene.

Trilophodon (Tetrabelodon) shepardi edensis Frick, 1921. "Extinct Vertebrate Faunas of the Badlands of Bautista Creek and San Timoteo Cañon, Southern California." Univ. Calif. Publ., Geology, Vol. XII, No. 5, Dec. 28, 1921, pp. 405–409. TYPE.—(*Op. cit.*, p. 405): "The portion of a skull and posterior maxillaries, containing the last molar of the left side and a section of that of the right side, Univ. Calif. Coll. Vert. Pal. no. 23501 (fig. 160); two associated molars from the left and the right side respectively, Univ. Calif. Coll. Vert. Pal. 23503, 23504 (figs. 164, 162)." HORIZON AND LOCALITY.—Mt. Eden Hot Springs, San Bernardino County, Californa; Upper Pliocene. NEOTYPE.—A partial skull (F:A.M. 18225) with complete mandible and dentition (Figs. 478G, 479 of the present Memoir), from Uppermost Pliocene deposits to the east of Mt. Eden, southern California.

GEOLOGIC AGE.—(Frick, 1933, p. 516) The fauna affords the best known representation of the American Uppermost Pliocene, including the typical *Pliohippus edensis* Frick.

MATERIALS.—The confused history of this species is fully recited above in the present chapter XI (pp. 496–501, fig. 470, Univ. Calif. 23501), in which it is seen that the type grinding teeth originally described as "*Trilophodon (Tetrabelodon) shepardi edensis*" Frick, 1921 (see Fig. 470, p. 497), were found in the same quarry with the twisted tusks now known to be referable to *Cordillerion edensis* Osborn (see Fig. 471). Fully confirming the presence of a true Rhynchorostrine in the Eden quarry is the juvenile specimen (see Fig. 474, p. 500) referable to the same species, *Rhynchotherium shepardi edense*, rather than to *R. paredensis* Osborn, 1929 (Amer. Mus. 18216B and 18218), a synonym. Finally, from the same Eden quarry, Messrs. Joseph Rak and Guy E. Hazen discovered in December, 1931, another immature jaw and partial cranium (F:A.M. 18225) which Frick described (1933, p. 512) as an 'adolescent neotype' of *Rhynchotherium edense* Frick, this recent description being as follows (pp. 514, 515, fig. 1, reproduced herewith as figure 479):

"A partial skull [F:A.M. 18225] with complete mandible and dentition (Fig. 1) and limb elements from the Uppermost Pliocene deposits to the east of Mt. Eden, southern California, afford the first evidence of several special characters of the peculiar mastodont genus, *Rhynchotherium*. . . . The new partial skull and mandible are unique in exhibiting the existence of a heretofore unseen adaptation between the upper and lower tusks. This adaptation suggests an hypothesis as to there having been a shear-like action between the respective inferior and externolateral enamel bands of the opposed upper and lower tusks, and the original *raison d'être*, perhaps, of the enamel bands common to the superior incisors of Tertiary mastodonts. The enamel adaptation immediately recalls that of the rodent incisors. The retention of the enamel bands on the inferior tusks may well be interpreted as a primitive character. . . . An examination of the wear of the opposed tusk surfaces suggests that the upper pair of tusks crossed the lower pair some 6 inches behind the tips of the latter, and thus that the downward directed tips of the upper tusks only slightly cleared the external edges of the lower pair. The worn surfaces indicate that the tip of an upper tusk at times collided with the dorsal surface of a lower tusk and that an upper tusk at times was brought between the lower tusks. The relatively far greater wear of the upper right tusk (Fig. 3) shows that the particular individual was very definitely 'right-handed.' The study of the surfaces of the opposed pairs of incisors of this new Eden specimen (see Figs. 1 and 3) suggests that *Rhynchotherium* may have subsisted largely on the vegetation of marshes and ponds, its shear-like incisors and depressed mandibular symphysis possibly being adapted to the quick severing of the slimy roots of succulent water-plants. The interesting manner in which this depressed-beaked genus differs from the earlier appearing and undepressed-beaked Longirostrine mastodonts through the apparent general absence of vertical successors to the milk premolars of both jaws was first observed in the writer's previous study (1926) of the referred immature Eden specimens."

SKELETON OF RHYNCHOTHERIUM

See restorations (Figs. 447 and 477)

New and valuable is the skeleton of the adolescent neotype (F:A.M. 18225) indicating (Figs. 478, 482) an animal equal in size to Osborn's *Rhynchotherium falconeri* type, slightly inferior in size to Osborn's *R. browni* type.

So. California	*Rhynchotherium edense* Frick, neotype	M_3, ap. 176 mm.
Texas	*Rhynchotherium falconeri* Osb., type	M_3, ap. 173
Mexico	*Rhynchotherium browni* Osb., type	M_3, ap. 176

The lengths of the limb elements are as follows:

Humerus		660 mm.	Femur		860 mm.
Radius		500	Tibia		490
Radio-humeral ratio		76%	Tibio-femoral ratio		57%
Metacarpal	1	70	Metatarsal	1	45
	2	110		2	70
	3	125		3	85
	4	110		4	80
	5	90		5	55

These limb measurements indicate a shoulder height in the flesh of approximately 2000 mm. or 6 ft. 6¾ in. in comparison with the estimated shoulder height in the flesh of *Serridentinus productus* (1727 mm. or 5 ft. 8 in.).

The relative sizes and heights of other known Rhynchorostrines as restored from cranial measurements only are shown in figure 477.

CONTEMPORARY UPPER MIDDLE PLIOCENE FAUNA AND FLORA OF EDEN, SOUTHERN CALIFORNIA

Extremely valuable also is our new knowledge (Frick, 1933) of the contemporary fauna and flora of the upper Middle Pliocene of the Mt. Eden region of the Mohave desert of southern California (cf. *op. cit.*, p. 516).

Fauna

Pliohippus-like species:
- *Pliohippus osborni* Frick
- *Pliohippus edensis* Frick

Teleocerine rhinoceros

Prochenia edensis Frick, a small camel

Pliauchenia merriami Frick, a huge camel

Antelopine and Cervine forms

Prosthennops edensis Frick, a suilline

Platygonus ?sp., a suilline

Nothotherium ?sp., California edentate

Megalonyx ?sp., California edentate

Hypolagus edensis Frick

Feline

Hyænognathus ?sp.

Hyænarctus gregorii Frick

Plionarctus edensis Frick

Procyonine or raccoon-like type

The characteristic upper Middle Pliocene flora, as determined by Dr. Ralph W. Chaney, includes:

Flora

Broad-sclerophyll element:
- *Arbutus* ?sp.
- *Quercus hannibali* Dorf

[cool, dry climate]

Riparian type:
- *Platanus paucidentata* Dorf
- *Populus alexanderi* Dorf
- *Salix coalingensis* Dorf

Chaparral type:
- *Ceanothus chaneyi* Dorf
- *Pinus pieperi* Dorf
- *Rhus* ?sp.

This flora, lacking representatives of the more humid elements recorded from coastal California, represents a vegetation where the rainfall was 15 inches or less a year, and where the trees were largely restricted to the borders of streams with chaparral and pines on the slopes above, a flora equivalent to that now observed on the landward slopes of the Coast Ranges and in sufficiently moist habitats in the Great Valley of California. The modern aspect of the flora indicates a rather cool, dry climate.

Blickotherium blicki Frick, 1933

Figures 478, 479, and 482

From near Tapasuma, Gracios, Honduras. Pliocene.

Blickotherium blicki Frick, 1933. "New Remains of Trilophodont-Tetrabelodont Mastodons." Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, March 2, 1933, pp. 509, 515, 527–531. TYPE.—(*Op. cit.*, p. 529) "Adolescent mandible with p_4, m_1, m_2 (erupting) of both sides, and major portions of both tusks. F:A.M. 27062." [M_1, M_2, M_3—Osborn] HORIZON AND LOCALITY.—From vicinity of Tapasuma, Gracios, Honduras. Pliocene. TYPE FIGURE.—*Op. cit.*, figs. 3 and 4.

GENERIC CHARACTERS OF BLICKOTHERIUM.—Frick (1933, p. 527) ranks the following as generic characters: (1) Peculiarly formed symphysis; (2) laterally compressed, enamel-banded incisors; (3) peculiar mode of wear of the incisors; (4) the apparent presence of a replacement P_4; (5) the elongation and relatively moderate depression of the symphysis. This genotypic description refers to the 'adolescent' specimen (F:A.M. 27062).

The above characters are regarded by Osborn as of generic value and of full generic rank; certainly *Blickotherium blicki* represents a distinct line of adaptation. This Honduras species therefore, is cited as *Blickotherium blicki*, Frick, 1933.

GEOLOGIC HORIZON.—(*Op. cit.*, 1933, p. 527): "The occurrence of Tertiary mammal remains in the vicinity of Tapasuma, Honduras, was first reported to the Museum by Mr. A. W. Anthony. The latter had visited this area in 1927 during the course of a collecting trip for the Department of Mammals, and had secured four teeth of a small *Hipparion*-like form and a mastodont premolar. . . . Two extraordinary mandibles, the one an adolescent specimen [F:A.M. 27062] with p_4-m_2 and peculiarly formed symphysis containing very Rhynchothere-like laterally compressed and enamel-banded incisors (Fig. 4 [see Figs. 479, 478H]), . . . were secured from an Honduras horizon of Upper Pliocene facies by Mr. John C. Blick in the winter of 1929."

HISTORY.—The first references by the author to this species are as follows:

(p. 515) "The only other mastodont known to the writer in which the lower tusks are of somewhat similar cross-section, or similarly banded with enamel, is that from Honduras described in the next section under *Blickotherium blicki*, n.g. and sp."

(p. 527) "The combination of characters in the Blick adolescent mandible is unique—for while the laterally compressed and externally heavily banded incisors differ from all Longirostrine species, as at present known, and at once suggest *Rhynchotherium*, the wear of the incisors, the apparent presence of a replacement p_4 and the elongation and relatively but moderate depression of the symphysis separate the specimen very definitely from the genus, *Rhynchotherium*, as now understood."

MATERIALS.—The genotype is the nearly complete immature mandible (F:A.M. 27062), an adolescent specimen with M_1, M_2 in use and the tetralophoid r.M_3 partly buried in the jaw, with strongly compressed lateral incisive tusks and broad enamel band, as well represented in Frick's type figure (1933, p. 526, fig. 4), reproduced

in the present Memoir as figure 478H after Frick: "Fig. 4. F:A.M. 27062, *Blickotherium blicki*, n.g. and sp., genotype (p_4 restored from opposite)." Osborn in the present Memoir (p. 489) refers '*Mastodon*' *euhypodon* (Amer. Mus. Cope Coll. 8528) to the genus *Blickotherium*, possibly ancestral to *B. blicki*.

slender type of *Rhynchotherium* [*Blickotherium*] *euhypodon* Cope (Fig. 478B).

Generic Characters of Aybelodon (Frick-Osborn).—(1) Inferior incisors large, broad, closely appressed, upcurved, without trace of enamel band; (2) symphysis extremely elongate,

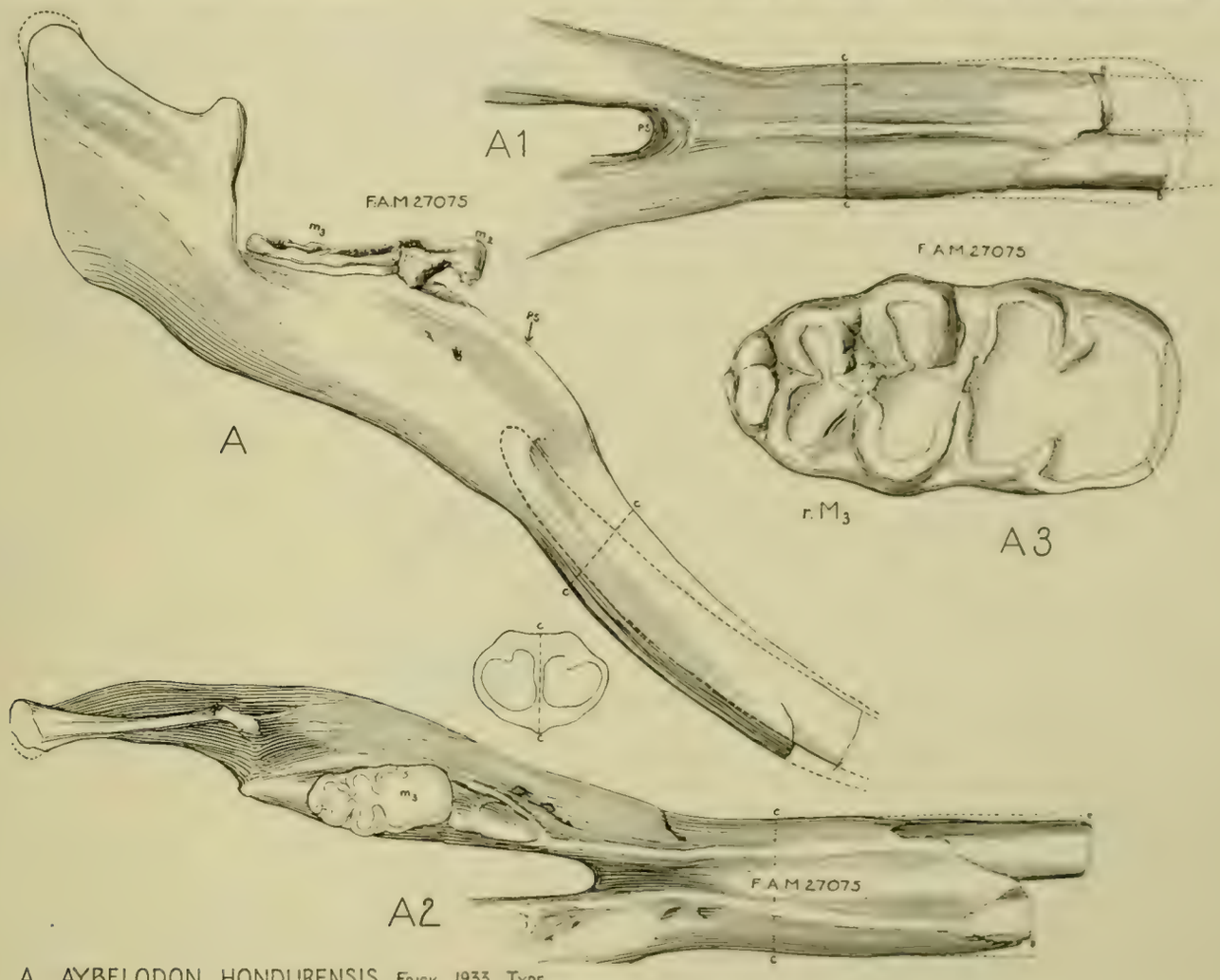


Fig. 480. Rhynchorostrine. Aybelodon hondurensis Frick, 1933, Genotype Mandible from near Tapasuma, Honduras, Central America

Mandible about one-fifth natural size; molar seven-seventeenths natural size. See figures 478 and 482 of the comparative series of Rhynchorostrine jaws.

A, Genotype mandible, length 1180 mm. (F:A.M. 27075). After Frick, 1933, fig. 5.

A1, Same, inferior aspect, after Frick, 1933, fig. 5; A2, superior aspect, fig. 18.

A3, Same, third inferior molar, r.M_3, 4½ ridge-crests, ap. 173 mm., tr. 76 mm., index 44. After Frick, 1933, fig. 5.

Aybelodon hondurensis Frick, 1933

Figures 478, 480, and 482

From near Tapasuma, Gracios, Honduras, Central America. Pliocene.

The name *Aybelodon* (Frick, letter, Sept. 26, 1933) signifies "A" recalling *Amebelodon* with which the subgenus was grouped in the "Superlongirostrines" (Frick, 1933, p. 547).

This is certainly the longest and most slender mandible and rostrum thus far observed; the nearest resemblance to it is the laterally compressed, upcurved; (3) first and second inferior molars small, dehiscent in early age; (4) third inferior molars relatively broad and short with very thick enamel, ap. 173 mm., tr. 76 mm., index 44, as compared with *Rhynchotherium falconeri*, ap. 173 mm., tr. 80 mm., index 46, or with *B. euhypodon* type, ap. 182 mm., tr. 78 mm., index 43; (5) ridge-crests of M_3 4½; (6) mandibular rami of the long, relatively slender type (see Fig. 478).

Specific Characters of Aybelodon hondurensis (Frick-Osborn).—Partly included above. Total length of aged mandible,

condyle to symphysis, 1180 mm.; depth below anterior end of M_3 170 mm.; symphysis extremely narrow, transverse exceeding vertical diameter, as contrasted with *Rhynchotherium blicki* (see below).

Aybelodon hondurensis Frick, 1933. "New Remains of Trilophodont-Tetrabelodont Mastodons," Bull. Amer. Mus. Nat. Hist., Vol. LIX, Art. IX, pp. 527, 528, 532, 533. TYPE.—. . . "a mature mandible with unusually elongated symphysis and extremely heavy buffer-like incisors (Fig. 5) [p. 527] . . . Large, aged, mandible with m_2, both m_3s and broken tusk bases [p. 532]." An aged mandible (F:A.M. 27075), left ramus and symphysis, and left inferior incisive tusk nearly complete; posterior portion of right ramus wanting; second inferior molars dehiscent, third inferior molars with fourth to third ridge-crests much worn, as shown in figure 480 A–A3. Left mandible reversed to right side in drawing. HORIZON AND LOCALITY.—(Cf. *op. cit.*, p. 528): The particular Tapasuma, Honduras, deposit, on the basis of the fragmental and as yet undescribed fauna secured by Mr. Blick, is interpreted as representing the Upper Pliocene: [*Blickotherium blicki*, *Aybelodon hondurensis*], *Hyænognathus* ?sp., *Pliohippus* ?sp., *Hipparion* ?sp., *Merychippus* ?sp., *Protohippus* ?sp., *Teleoceras* (teleocerine rhinoceros), *Procamelus* ?sp. TYPE FIGURE.—*Op. cit.*, figs. 5, 13, and 18.

GENERAL CHARACTERS.—Of the genotypic specimen (F:A.M. 27075) the author observes (*op. cit.*, p. 527): "The inferior tusk of the adolescent specimen [*Blickotherium blicki*] is not of corresponding cross-section with that of the aged mandible, the tusk of which in turn is without any visible suggestion of the extremely characteristic enamel band of the former. It is, of course, possible that in the aged specimen the enamel may have been once present and then lost in advanced maturity, much as the enamel of the upper tusks seems to tend to be reduced to lost with increasing age in certain Longirostrine individuals. (Compare specimens figured, Fig. 2). Neither the cross-sections of the great tusks of the aged mandible, nor the elongation and straightness of its symphysis, nor the unusual keel of its ventral surface (see cross-sections) indicates that this large mandible might be of the same species as the adolescent specimen. The range of size in the entire Honduras series, as observed in a comparison of the largest and smallest m^3s [M_3] from the one locality, is 20 per cent. . . . . For convenience, to the latter species [*Aybelodon hondurensis*] are tentatively referred detached mastodont remains from the same Honduras area. Such remains include an immature ramus with p_4 germ (possibly better referred to the first species), two toothless rami and some seventeen teeth . . . etc. specimens listed below."

MATERIALS.—The materials are described and designated by Frick (1933, pp. 532, 533) and partly figured (figs. 4 and 24). Besides the type, the following specimens are referred, some of which may belong to *Blickotherium blicki:*

Immature rami: F:A.M. 27060 (Fig. 4), 27061, 21944 (Fig. 4).

Mature remains: F:A.M. 27076 (Fig. 24), 27070, 27071, 27069 (Fig. 24), 27066, 27067, 27068, 27064, 27065, 27072, 27077, 27078, 27079A–E, 27073, 27074.

[1](( )) = estimated.

CHARACTERS OF THE TYPE MANDIBLE.—(Frick, 1933, p. 532, fig. 5): "The vertical ramus, condyle and coronoid process are low. The symphysis is strong and straight and very elongate, and the inferior surface is furnished with a peculiar keel. The inferior tusks are of unusually heavy cross-section, concave inwardly and with the depression of the superior outer contour continued to the dorsoventrally narrowed tusk-roots, which extend well posterior of the main mental foramen and to within 20 mm. of the posterior symphysis. There is no suggestion of the presence of an enamel band. The last molars and m_2 are retained and much worn. The absence of the distal extremity of the symphysis forbids exact determination of the elongation of the latter, which at the least must have been unusual."

REFERRED.—In the superior tusks, the author cites proof of the characteristic enamel band (p. 532): "An anterior section of a tusk (F:A.M. 27075A), possibly representing a distal section of the upper left side, found in association with the mandible, is of somewhat smaller cross-section than the preserved posterior portions of the inferior tusks of the latter specimen. The particular tusk section exhibits a tendency toward inward and forward curvature. The presumed outer surface has the remnants of an enamel band. The presumed inner side is noticeably flattened (possibly through contact with the trunk) and the superior surface flat and seemingly somewhat gouged."

Table (*op. cit.*, p. 528) modified by Osborn	*Aybelodon hondurensis* type F:A.M. 27075	*Blickotherium blicki* type F:A.M.27062	*Rhynchotherium edense* neotype F:A.M. 18225
m_1	. . . . .	47.7 mm.	104e
m_2	((110))[1] mm.	86	128
m_3	173	119	176
p.s.-alv. pouch	400		400
p.s.-i. br.	((492+))		
Tusks:			
Estimated length	. . . . .	330	?
Vertical diameter	70	48	
Transverse diameter	61	29	
Jaws:			
Mandibular length	1180	625	670

Osborn, 1933: The type inferior incisors exhibit no trace of the enamel band which is the most distinctive character of the subfamily Rhynchorostrinæ. As Frick observes (p. 527—cited in full above) . . . "of the aged mandible, the tusk of which in turn is without any visible suggestion of the extremely characteristic enamel band. . . . It is, of course, possible that in the aged specimen the enamel may have been once present and then lost in advanced maturity."

9. SUMMARY OF THE EVOLUTION OF THE RHYNCHOROSTRINES

These animals are the rarest of all the mastodonts and it has proved extremely difficult to work out their evolution from the few fractured and widely scattered specimens which have come to the author's knowledge.

Fig. 481. *Rhynchotherium* types as mounted in the American Museum uniformly reduced to about one-fifteenth natural size.

A, *Rhynchotherium falconeri* type
B, *Rhynchotherium browni* type
C, *Rhynchotherium shepardi edense* type
D, *Rhynchotherium* [*Blickotherium*] *euhypodon* type
E, *Rhynchotherium rectidens* type tusks (cranium restored in plaster)
F, *Rhynchotherium shepardi* type tusks (cast) (cranium restored in plaster)
G, *Rhynchotherium chinjiense* type lower jaw

Referring to the subfamily and generic distinctions of the Rhynchorostrines enumerated above, we may add the following list of persistent primitive and progressive characters in the evolution of these singular mammals:

Persistent Primitive Characters

1) Grinding teeth persistently brachyodont or short crowned; no evidence of hypsodonty or deposition of cement. Enamel unusually thick.

2) Simple *external* trefoil spurs on inferior molars and *internal* trefoil spurs on superior molars; no trace of doubling of the trefoil spurs; inferior trefoils rudimentary or wanting in *Rhynchotherium chinjiense* (Fig. 476). Inferior 'central conules' variable, superior 'central conules' absent.

3) Third superior molars relatively broad and short, with from three and a half ridge-crests (*Rhynchotherium brevidens*) to four plus ridge-crests (*R.* [*Blickotherium*] *euhypodon*); two conelets on the summits of the cones.

4) Third inferior molars less elongate than in *Trilophodon*, proportions as in *Serridentinus*, with two conelets on the internal cones (*R. anguirivale*), external trefoils confluent on prolonged wear (*R. anguirivale* — Fig. 465), thick, blunt enamel borders (*R. anguirivale*, *R. falconeri*), four plus ridge-crests and two supplementary conelets representing the pentalophid.

5) Second superior and inferior molars persistently trilophodont. Third and fourth superior milk premolars also trilophodont (*R. shepardi edense* ref.—Fig. 474).

In contrast to these non-progressive grinding teeth characters we observe the following:

Progressive Characters

6) Superior incisive tusks progressive, elongated, and laterally flattened, with broad persistent external enamel band, as shown in a comparison of *R. shepardi* (Fig. 459), *R. rectidens* (Fig. 461), and *R.* [*Blickotherium*] *euhypodon* (Fig. 462).

7) Inferior tusks progressive, compressed laterally, elongated, upturned, with persistent lateral enamel band, as shown in comparison of *R. shepardi* (Fig. 459), *R. browni* (Fig. 467), *R.* [*Blickotherium*] *euhypodon* (Fig. 462), *R. falconeri* (Fig. 468), *R. shepardi edense*, immature (Fig. 474), *Blickotherium blicki* (Figs. 478H, 479); tusks entirely without enamel, *Aybelodon hondurensis* (Figs. 478F, 480).

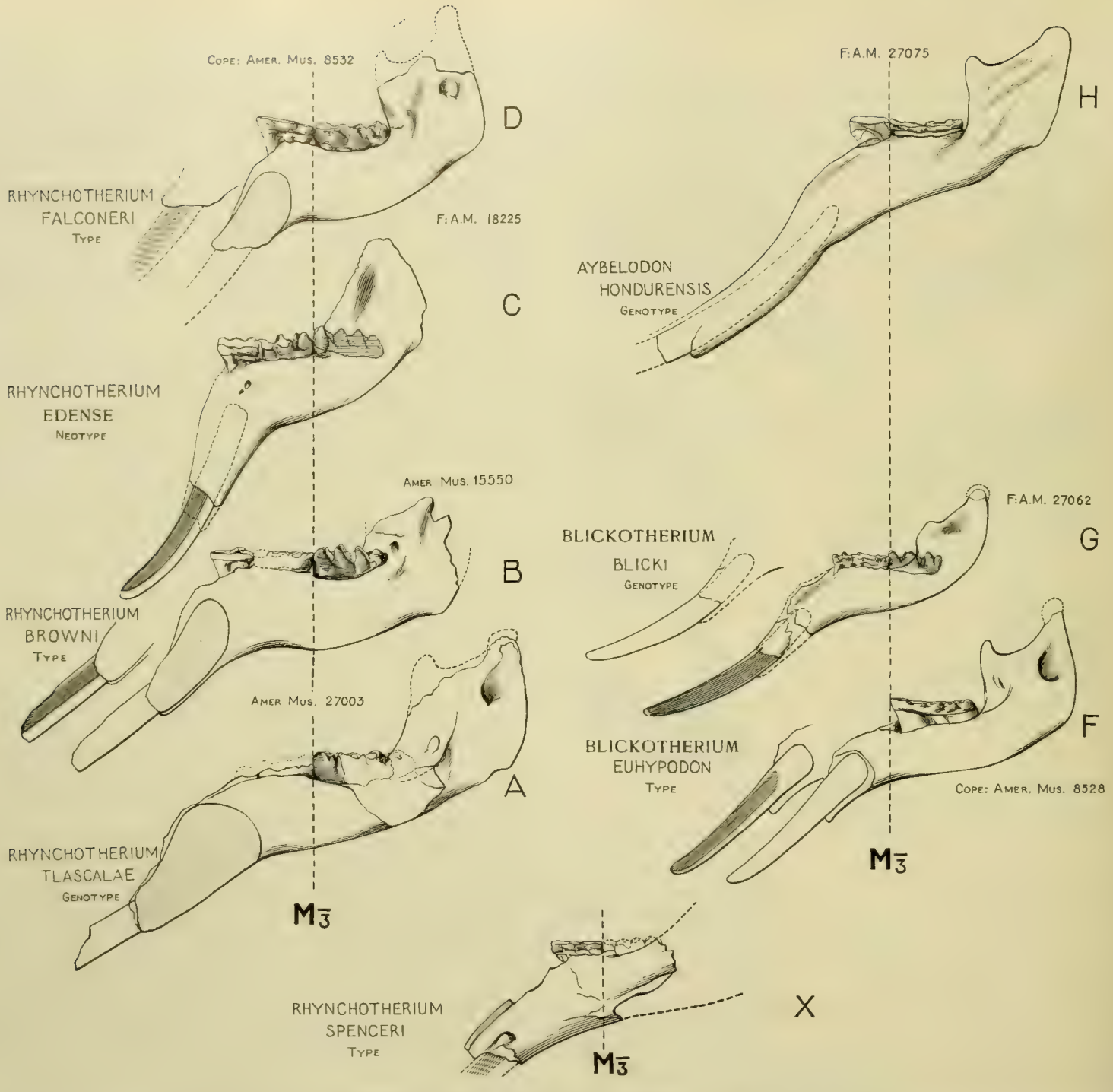


Fig. 482. Triphyletic Evolution of the Rhynchorostrinæ. Compare Figure 478

Recent discoveries by Frick and others demonstrate clearly that the Rhynchorostrinae are not monophyletic but triphyletic; they subdivide into three wholly distinct lines of generic descent, obviously in adaptation to the search for three different kinds of food in three different habitats.

Rhynchotherium

Relatively massive jaws progressively abbreviated and deflected.

(D) *R. falconeri.* Ramus strongly abbreviated, sharply deflected, retaining second and third grinders only.

(C) *R. edense.* Ramus sharply deflected, retaining first, second, and third molars.

(B) *R. browni.* Ramus less deflected, relatively more elongated, retaining first, second, and third molars.

(A) *R. tlascalæ.* Ramus relatively long and powerful, less deflected, retaining first, second, and third molars.

Blickotherium

(G) *Blickotherium blicki.* Mandible much more slender, less sharply deflected, retaining first, second, and third molars.

Possibly ancestral to *Blickotherium blicki.*

(F) *Blickotherium euhypodon.* Ramus slender, rostrum less deflected, retaining third molar in adult stage.

— — —

Possible ancestral form of northern Egypt.

R. spenceri. Ramus moderately deflected, retaining second and third molars.

Aybelodon

(H) *Aybelodon hondurensis.* Differing from the other Rhynchorostrines in the total absence of enamel on the incisive tusks. Imperfectly known. Mandible extremely long and slender; adult retaining second and third molars. Rostrum also extremely long and slender, slightly upturned. Coronoid, condylar, and angular borders quite different from those of *Rhynchotherium* or *Blickotherium.* Probably of very different habits from either of the above genera.

8) The *abbreviation* and *deflection* of the rostrum of the lower jaw are most distinctive progressive characters, as shown in a comparison of *Rhynchotherium spenceri* (Fig. 455), *R.* [*Blickotherium*] *cahypodon* (Fig. 462), *R. browni* (Figs. 467, 478D, 482B), *R. falconeri* (Fig. 468), and *R. shepardi edense* (Fig. 478G).

Finally, in *Rhynchotherium falconeri*, the characteristic upper concavity and symphysis of the rostrum are obliquely deflected downwards. Accordingly the *abbreviation and deflection of the rostrum* are highly distinctive progressive characters of the Rhynchorostrines.

The strongly compressed superior tusks were apparently similar in function to the rounded tusks of *Trilophodon* and to the angulate-oval tusks of *Serridentinus;* this function may have partly assisted in pulling down the branches of trees, partly in offense and defense in the contests between the males. The upturned, enamel-bordered inferior tusks, on the other hand, which appear to increase in length and in vertical diameter, were doubtless used in an upward action, because of their upcurved and deep vertical section calculated to resist vertical strain; the progressive reduction in the length of the lower jaw, in widest contrast to the progressive elongation of the lower jaw in *Trilophodon*, does not preclude the idea that the lower tusks reached the ground for purposes of uprooting tuberous or other plants; consequently the precise function of the lower tusks is difficult to surmise.

While these important functional changes were taking place in the upper and lower incisive tusks and in the rostrum of the jaw, the grinding teeth remained relatively unchanged, simple, brachyodont, with single trefoils, three ridge-crests in M_2 and four plus ridge-crests in M_3; these grinding teeth, therefore, must be closely examined to distinguish them from those of the more primitive species of *Trilophodon* and of *Cordillerion*. In figuring and describing the third inferior and superior grinders of *Rhynchotherium*, we have given invariable marks of distinction which appear on careful examination. This distinction of *Rhynchotherium* grinders from those of *Cordillerion* is all the more important, because in southern California and in Mexico the range of the species belonging to these two genera completely overlaps.

Rarity.—Finally, we are disposed to explain the rarity of the Rhynchorostrines as due to their forest-loving habits in contrast to the savanna- and plains-loving habits of *Trilophodon* and the widely ranging species of *Cordillerion.*

Hopwood (letter, Feb. 10, 1932) remarks that the evidence for the occurrence of *Rhynchotherium* in the Siwaliks of India is very slender. In the Museum of Calcutta there are one or two decurved, medirostral symphyses, and in the British Museum there is one symphysis from the 'lower horizon' of the Middle Siwaliks, presumably the Nagri, of Mithrala in the Attock District; in this last specimen the tusks are broken off short, and it is not possible to observe whether they have lateral enamel bands or not, but their vertical diameter is in excess of the transverse diameter, this appearing to be one of the main characters of *Rhynchotherium*.

Fig. 483. Theoretic migration lines of the Rhynchorostrinæ

(5) *Rhynchotherium spenceri*, North Africa. (11) *Rhynchotherium chinjiense* of India. (1, 3, 4, 6–10, 14) Main line of *Rhynchotherium*. (2, 12) Side line of *Blickotherium*. (13) Side line of *Aybelodon*.

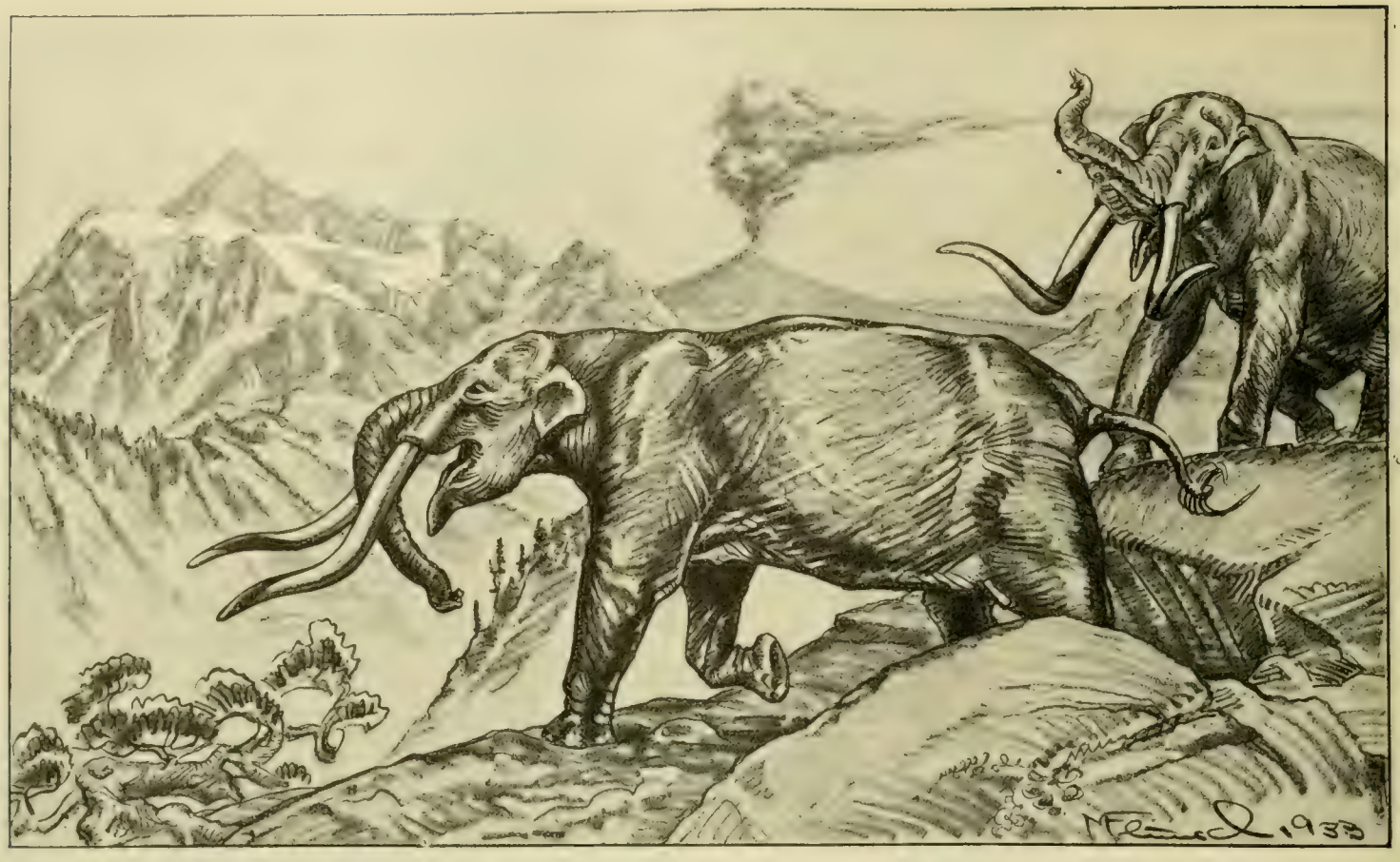


Fig. 484. The Mastodont of the Cordilleras (Cordillerion andium) among the volcanic peaks of the Bolivian Andes near Tarija
Restored under the Direction of Henry Fairfield Osborn by Margret Flinsch (1933) to a one thirty-sixth scale

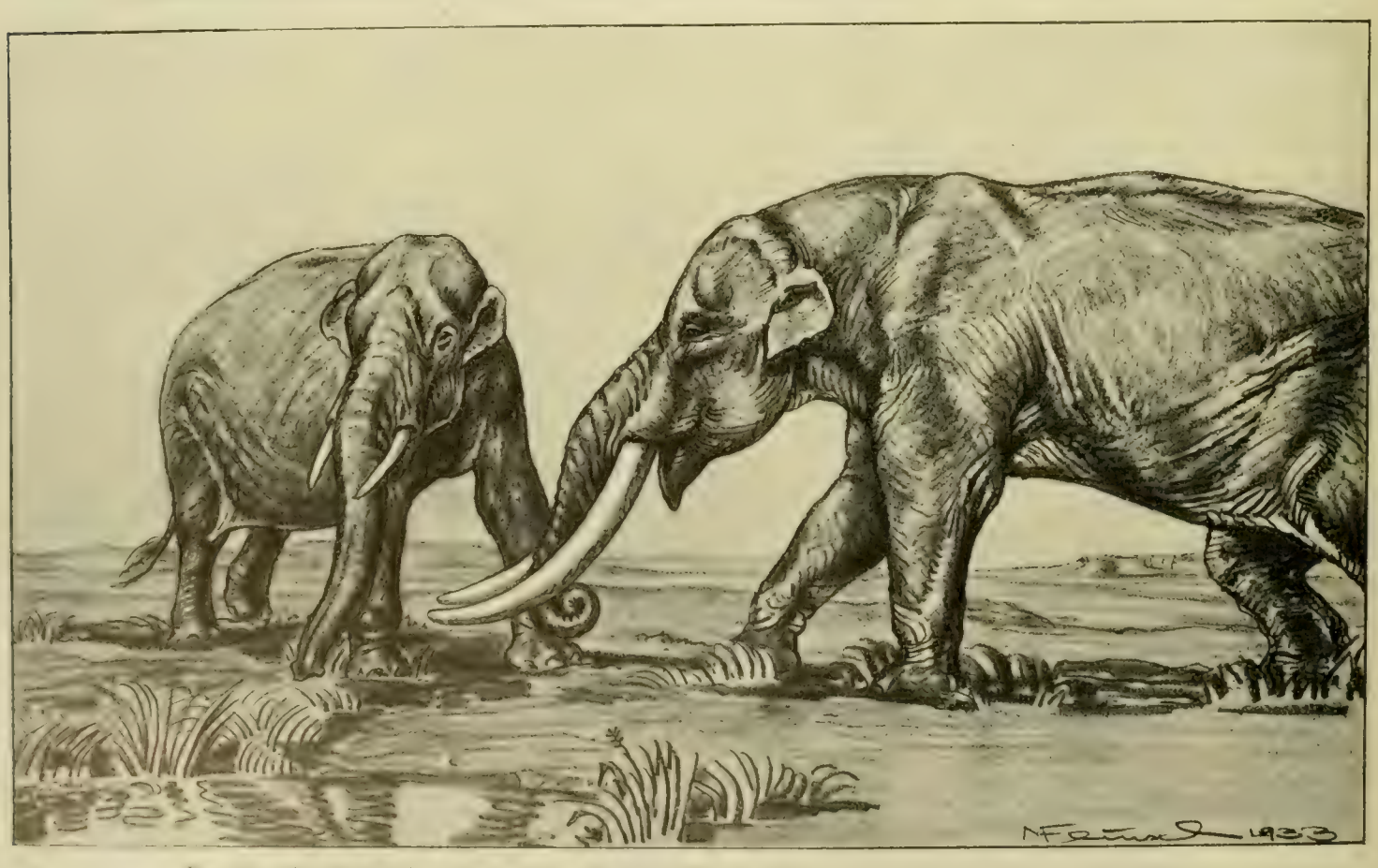


Fig. 485. The Giant Mastodont of the Argentine Plains (Cuvieronius superbus), Male and Female
Restored under the direction of Henry Fairfield Osborn by Margret Flinsch (1933) to a one thirty-sixth scale

Chapter XII

THE SOUTH AMERICAN MASTODONTS, OF THE GENERA CORDILLERION, CUVIERONIUS, AND NOTIOMASTODON

Cuvier's classic types of "mastodonte des cordilières" and "mastodonte humboldien." Successive discoveries of andean and of pampean species, also of north american ancestors. Theories of phylogeny and relationships. Final separation of the notorostrines into cordillerion and cuvieronius. Discovery in the western and southern united states. Inclusion of eubelodon in the humboldtinæ as ancestral to cuvieronius; also of stegomastodon. Reference of Notiomastodon to the serridentinæ.[1]

I. Historical Introduction.
1. Period of Cuvierian description (1806–1824).
2. Amplification by Desmarest, de Blainville, D'Orbigny, Laurillard, and Gervais (1818–1855).
3. South American species and materials (Lund, Ameghino, Moreno, Philippi, Nordenskiöld, 1837–1903, Carette, 1919, Boule, 1920).
4. Discovery of Mexican and North American species. Phylogenetic and specific revisions by Cope, Lull, and Boule (1884–1920).
5. The Notorostrines described from Mexico (Cope, Felix, Villada, Freudenberg, 1884–1922).
6. Tambla tooth of Central America.
7. California, Texas, and Arizona species.
8. Order of discovery and description of thirty South American and North American species.

II. Synopsis and Phylogenetic Revision up to 1929.
1. Osborn's separation of the subfamily Notorostrinæ (1921–1926).
2. Osborn (1923–1926) separates the genera *Cordillerion* and *Cuvieronius*.
3. Systematic revision of the genus *Cordillerion* and its included species up to the year 1927.
4. New knowledge of *Cuvieronius* afforded by recent discoveries in Bolivia (Tarija) and in Ecuador (near Punin and Alangasi).
5. Systematic revision of the genus *Cuvieronius* up to the year 1935.
6. Synopsis and critique of Dr. Ángel Cabrera's Revision of the Argentine Mastodonts, including the new genus and species *Notiomastodon ornatus*.

III. Description of Eubelodon morrilli of Nebraska, with resemblances of Eubelodon to Cuvieronius.
1. Description of *Eubelodon morrilli* type, of Nebraska.
2. Referred skull and tusks of *Eubelodon morrilli*, Frick Pliocene Collection.

IV. Synopsis (1934) of the Notorostrine and Humboldtine Mastodonts of South and North America.

I. HISTORICAL INTRODUCTION

(Osborn, 1935) The Notorostrinæ (Osborn, 1921–1926), as revealed by recent discoveries, have been reclassified as follows: (1) The mastodonts typified by *'Mastodon' andium* are true Notorostrines; (2) the Humboldtinæ (Osborn, 1934.922, .924, .926) of the Humboldtidæ fam. nov., embrace the genera *Cuvieronius*, *Eubelodon*, and *Stegomastodon*; (3) *Notiomastodon* Cabrera, 1929, genotype *N. ornatus*, referred species *N. argentinus* Ameghino, proves to belong to the Serridentine mastodonts, for the reception of which Osborn has made the new subfamily Notiomastodontinæ (see this Chapter, pp. 590–592, also Appendix to the present Volume I).

The historical introduction of the present chapter is devoted to a long and detailed account of the discovery and final recognition of the distinctive characters of the mastodonts peculiar to South America. It is certainly remarkable that whereas four subfamily branches of the Proboscidea extended as far as the great plateau of Mexico, namely, the Rhynchorostrines, the Serridentines, the Notorostrines, and the Archidiskodonts, to our present knowledge only three kinds of mastodonts, and one species of *Parelephas*, succeeded in crossing the equatorial forest belt north and south of the Isthmus of Panama and in penetrating the great continent of South America.

The members of these fortunate migrants enjoyed this great South American theatre for their adaptive radiation into mountain-loving and plains-loving mastodonts, in many features wholly distinctive, in other features paralleling their North American and Eurasiatic relatives.

[1] *Notiomastodon* made the type of the Notiomastodontinæ subfam. nov., of the new family Serridentidæ (see Appendix to present Volume I).

It is not surprising, in view of the close similarities between the grinding teeth of '*Mastodon*' *andium* and those of *Trilophodon angustidens*, and the teeth of '*M.*' *humboldtii* and those of *Tetralophodon longirostris*, that it has required a hundred and twenty years of research to establish on other characters the independent subfamily history of the Notorostrinæ, as well as the clear separation of the generic phylum *Cordillerion* of the Andes from the generic phylum *Cuvieronius* of the plains.

1. PERIOD OF CUVIERIAN DESCRIPTION (1806–1824)

The century-long bibliographic history of this subfamily begins in 1806 with Cuvier's description of the *Mastodonte des Cordilières* and concludes with the names applied by Frick (1921), Freudenberg (1922), Hay (1926), and Gidley (1926), to northerly species recently discovered in southern California, Mexico, Texas, Nebraska, and Arizona respectively.

Confused Nomenclature.—The early specific nomenclature was confused by Cuvier's failure to apply consistently the binomial system of Linnæus, so that his *Mastodonte des Cordilières* (=*Mastodon andium*) was confused with *Mastodonte humboldien* Cuvier, 1806 (=*Mastodon humboldtii* Cuvier in Desmarest, 1818), and *Mastotherium hyodon* Fischer, 1814. Otherwise stated the history is as follows:

The first species described from South America was the *Mastodonte des Cordilières* Cuvier, 1806 (=*M. cordillerarum* Desmarest, 1820–1822=*M. andium* Cuvier, 1824); the second species was the *Mastodonte humboldien* Cuvier, 1806 (=*Mastodon humboldtii* Cuvier in Desmarest, 1818, *Mastodon Humboldii* Cuvier, 1824). It was not until 1824 that Cuvier applied the name *Mastodon andium* to the *Mastodonte des Cordilières*. The molar types of these two species were from the first very clearly distinguished by Cuvier and his successors by the possession of *single* trefoils (*M. andium*) and of *double* trefoils (*M. humboldtii*).

The only way to clear the confusion in the nomenclature is to adopt our standard rule, which carries us back to the original type descriptions and type figures of Cuvier contained in his writings of 1806, as follows:

La grande à dents carrées, *Mastodonte des Cordilières* [*op. cit.*, p. 413] [près du volcan d'Imbaburra, Quito, Ecuador	[=*Mastodon andium* Cuv., 1824, =*Mastodon cordillerarum* Desm., 1820-1822, =*Cordillerion andium* of Osborn, 1926]	Ann. Mus., VIII, pp. 411, 413, Pl. 67 [II], Fig. 1. (Type confirmed by de Blainville in his revision of 1839–64, p. 249)
Et la plus petite, *Mastodonte humboldien* [*op. cit.*, p. 413] [de la Conception du Chili]	[=*Mastodon humboldtii* Cuvier in Desmarest, 1818, p. 447=*Cuvieronius humboldtii* of Osborn, 1923]	Ann. Mus., VIII, pp. 412, 413, Pl. 67 [II], Fig. 5. (Type confirmed by de Blainville in his revision of 1839–64, p. 249)

'M. Andium' Cuvier, 1824.—We follow de Blainville and Falconer as well as all subsequent continental authors up to Marcellin Boule, and all American authors excepting Cope, in adopting Cuvier's specific name *andium*. The name '*M. cordillerarum*' Desmarest, 1820–1822, refers to the same type description of the *Mastodonte des Cordilières* Cuvier (1806.3) as that to which Cuvier's description refers when he applied the name '*Mastodon Andium*' in 1824. Technically, therefore, the species name *cordillerarum* Desmarest, 1820–1822, antedates the name '*M. Andium*' Cuvier, 1824, but since Cuvier clearly defined, figured, and distinguished this species in 1806 as *Mastodonte des Cordilières*, it seems to be palæontologic justice to adopt Cuvier's name *Mastodon* [=*Cordillerion*] *andium*. Desmarest garnered where he did not work, and it was probably not his intention to rob Cuvier of the specific name '*andium*' but to Latinize the term *Cordilières*, as we have Latinized Cuvier's generic term *Mastodonte*.

CUVIER'S TYPE FIGURES OF 'M.' ANDIUM (FIG. 486) AND OF 'M.' HUMBOLDTII (FIG. 487)

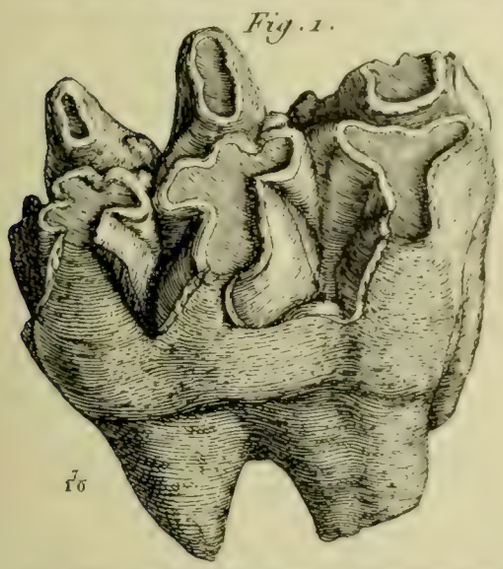


Fig. 486. Original type figure of *Mastodonte des Cordilières* Cuvier, 1806, Pl. 67 (II), fig. 1 = *Mastodon andium* Cuvier, 1824. A second molar. About seven-tenths natural size. From near Quito, Ecuador. This type belongs in the Muséum d'Histoire Naturelle, Paris, but could not be located for the writer during his visit of 1921; an r.M^2.

Observe *single* trefoils.

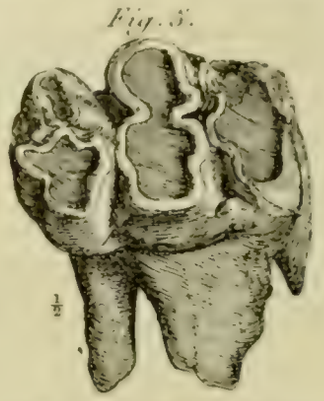


Fig. 487. Original type figure of *Mastodonte humboldien* Cuvier, 1806, Pl. 67 (II), fig. 5 = *Mastodon humboldtii* Cuvier in Desmarest, 1818. A first or second molar About one-half natural size. From near Concepcion, Chile. This type belongs in the Muséum d'Histoire Naturelle, Paris, but could not be located for the writer during his visit of 1921; r.M_1 or r.M_2.

Observe *double* trefoils.

THIRD SUPERIOR MOLAR OF CUVIERONIUS (UPPER), OF CORDILLERION (LOWER

Fig. 488. Third superior molar of *Mastodon* [= *Cuvieronius*] *humboldtii*: "9. Sixième molaire supérieure (de Buenos-Ayres)." After Gervais, 1855, Pl. v, fig. 9, one-third natural size. [= *Cuvieronius* (?)*platensis*.]

Third superior molar of *Mastodon* [= *Cordillerion*] *andium* "3. Sixième molaire supérieure [of Tarija, Bolivia]." After Gervais, 1855, Pl. v, fig. 3, one-third natural size.

In Fischer de Waldheim's "Zoognosia" of 1814, Vol. III, pp. 337–341, appears the following citation of Cuvier's species of *Mastodon* Cuv. = *Mastotherium* Fischer:

76. MASTOTHERIUM. *Dentes incisores* superiores duo, longissimi, sursum versi.
Canini nulli.
Molares coronâ elevatâ, tuberculis conicis s. mammillaribus.
Proboscis ut in Elephante.

Mostotherium [*Mastotherium*], Fischer; *Mastodonte*, Cuvier; *Harpagmotherium*, Fischer; *Elephas* Quorundam.

Nota. Nomen τὸ *Mastodonte* indicat animal cujus dentes molares habent coronam ex tuberculis mammillaribus formatam, a μαστος, mamma; auctor vero prætulit nomen τὸ mastotherium, ad legem generalem, a celeberrimo Cuvier ipso tacite consecratam, conservandam, secundum quam, animalia nimirum fossilia, ut terminatione, simili in *therium* in systemate indicentur, necessarium esse judicavimus.

Mastotherium convenit variis characteribus cum Elephante, cui proximus, et proboscide et dentibus inciscribus prominentibus. Differt vero ab eo molaribus tuberculatis, carnivoris propriis. Est itaque animal carnivorum formæ Elephantis.

Variis in regionibus ossa fossilia hujus animalis inveniuntur, inprimis in America septentrionali circa fluvium *Ohio*, in *Sibiria*, *Germania*, *Gallia*, *Italia* æque existunt, ut ex observationibus variorum constat. . . .

G. Cuvier, Sur le grand Mastodonte, animal très-voisin de l'éléphant, mais à mâchelières hérissées de gros tubercules, dont on trouve les os en divers endroits des deux continens, et surtout près des bords de l'Ohio, dans l'Amérique septentrionale, proprement nommé Mammonth par les Anglais et par les habitans des Etats-Unis.
V. Annal. du Mus. VIII. p. 270–312.

Idem Sur différentes dents du genre des Mastodontes, mais d'espèces moindres que celle de l'Ohio, trouvées en plusieurs lieux des deux continens.
ibidem. p. 401–424.

Cuvier opere hoc, ingeniose, uti solet, absoluto, quinque stabilivit species Mastotherii, quæ formâ et magnitudine molarium omnino inter se differunt:

1. *Mast. megalodon*, (le grand Mastodonte, Mastodonte de l'Ohio, Cuvier;) dentibus molaribus magnis, (ad 17 libras ponderantibus) tuberculis distantibus.
circa fluvium Ohio.

2. *Mast. leptodon*, dentibus molaribus, tenuibus s. compressis.
   le mastodonte à dents étroites Cuvier.
   in gallia (Simorre) et aliis regionibus Europæ, et Americæ.
3. *Mast. microdon*, dentibus molaribus minoribus. Petit mastodonte, à petites dents, Cuvier.
   in Saxonia, Montabusard, et alibi, similis simorrensi s. leptodonti, sed tertia parte minor.
4. *M. hyodon*, dentibus molaribus tuberculis intermediis cubicis s. tetrangularibus.
   le Mastodonte des Cordilières; Cuvier.
   Magnitudine accedit Mast. megalodonti.
   in America prope Cordilleras.
5. *M. Humboldtii*, similis præcedenti, sed tertia parte minor.
   Humboldt ossa hujus speciei prope Vulcanum *Imbaburra*, regni Quito, altitudine 1200 mensur. gall. (Toises) invenit.

As treated in the present Memoir, *Mastotherium hyodon* = *Cordillerion andium*, and *Mastotherium Humboldtii* = *Cuvieronius humboldtii*.

2. AMPLIFICATION BY DESMAREST, DE BLAINVILLE, D'ORBIGNY, LAURILLARD, AND GERVAIS (1818–1855)

From de Blainville's revision (1845) of the Proboscidea onward all French authors ignored the confusion in the names and all the specimens found in different parts of South America were referred either to *Mastodon andium* Cuvier or to *M. humboldtii* Cuvier-Desmarest, by de Blainville (Ostéographie, 1839–1864), D'Orbigny (Paléontologie, 1842, Pls. x and xi), Laurillard (Dictionnaire d'Hist. Nat., 1846, p. 30), and Gervais (Mam. Foss., 1855); the latter author published figures (Fig. 504) of referred posterior molars, M^3–M_3, valuable as amplifying the characters found in Cuvier's types which consist of second molars, M^2-M_2, in both species.

Consequently these two names have been recognized throughout the literature as founded on characters clearly displayed in the two types of Cuvier (Figs. 486 and 487). It would be a calamity to reopen the question of confused nomenclature and priority when these two names have been firmly established by over a century of usage and in thousands of publications.

3. SOUTH AMERICAN SPECIES (LUND, 1837–1841, AMEGHINO, 1888–1891, MORENO, 1888, PHILIPPI, 1893, NORDENSKIÖLD, 1903, CARETTE, 1919, BOULE, 1920)

The present Section I, 3, on South American species is continued in Section II, 4 and 6, of the present chapter.

In 1841 (1837) Lund described a mastodon from the caves of Brazil, but it is not very clear from his description whether he likened it to *Mastodon humboldtii* or to *M. andium*. In citing this description, Lesson gives the animal the name *Mastodon Brasiliensis* Lund. In the present Memoir this name is added to the list of species, without definition, as equivalent to *Cuvieronius brasiliensis*. While de Blainville (1839–1864), D'Orbigny (1842), Laurillard (1846), and Gervais (1855) greatly amplified our knowledge of the characters of these two species, as clearly set forth below in the descriptions of *Mastodon andium* and of *M. humboldtii*, they did not add to or change the nomenclature.

Consequently we may pass on to the works of Ameghino (1888–1891), of Moreno (1888), and of Philippi (1893), in which a considerable number of new specific names were added to the literature, based on types found in the Argentine and in the Andean regions respectively.

In 1903 very substantial additions were made by Nordenskiöld to our knowledge of *Mastodon andium* at Tarija, Bolivia, and for the first time both *M. andium* and *M. humboldtii* were clearly distinguished from each other by characters which Osborn in the present Memoir regards as of generic value.

In the year 1919 Eduardo Carette published his "Los Proboscideos Fósiles Argentinos," in which he reviewed the theories of Ameghino, Andrews, and Schlesinger on the origin and phylogeny of the Proboscidea, adopted (p. 171) a generic classification somewhat similar to that in the present Memoir, and presented (p. 173) a critical revision of the species of Cuvier, of Ameghino, and of Philippi, as reproduced in full below.

In 1920 this was followed by Marcellin Boule's Memoir based on equally fine materials collected in Tarija, which are fully discussed in his Memoir and presented in abstract in the present Memoir. Like Nordenskiold, Boule concludes that these mastodonts are chiefly referable to the two species *M. andium* and *M. humboldtii* included within the single genus *Mastodon*.

In all the above memoirs and papers there is constant adherence to the original terms of Cuvier and Desmarest, namely, *Mastodon andium* and *Mastodon humboldtii*, although Boule clearly recognizes that these two species are related, by the possession of single or double trefoils, not to the true *Mastodon* but rather to the bunomastodonts, deriving (p. 532 of the present memoir) both classic species from *Trilophodon angustidens*.

Meanwhile Cope published (1884.2) his paper on the "Extinct Mammalia of the Valley of Mexico," in which he combined the two species *M. andium* and *M. humboldtii* under his new genus *Dibelodon*.

In 1929 Ángel Cabrera completely revised the Notorostrines. In 1928–1931 Franz Spillmann added new primitive mastodonts [Humboldtines] from Ecuador.

Five New South American Species Proposed by Ameghino, 1888–1891

In his preliminary diagnosis of 1888, entitled "Rápidas Diagnosis de algunos Mamíferos Fósiles Nuevos," Ameghino described three new species of mastodonts from South America, namely, *Mastodon argentinus*, *M. platensis*, and *M. superbus*. This was followed in 1889 by his great Memoir "Contribucion al Conocimiento de los Mamíferos Fósiles de la República Argentina" in which he summed up his views on phylogeny and distribution (pp. 650–652), describing another new species, *Mastodon rectus* (p. 643). It was not until 1891, in his paper in the Revista Argentina de Historia Natural, Tome I, p. 243, that he gave the name *Mastodon maderianus* to the mastodont specimen found while excavating at Puerto Madero in Buenos Aires.

Ameghino in his Memoir of 1889 (pp. 633–653) gives a most full and valuable summary of the history of discovery of the mastodonts of South America, dating back to the first giant bones found in Tarija in 1602 and describing the successive observations of von Humboldt, Cuvier, D'Orbigny, Laurillard, de Blainville, and Gervais, and concludes with the following synopsis of species:

Ameghino, 1889, p. 639, as Translated from the Original Text.—Thus, instead of two [the two species of Cuvier], we have six distinct species of South American mastodons, characterized as shown in the following table:

I Internal cusps of the upper molars and external cusps of the lower molars broader, when worn they show a clover-leaf pattern.[1]
  A Height considerable—comparable to that of *Mastodon longirostris*.
    a Tusks slender, long, slightly curved, twisted (deflected) in a spiral, with a longitudinal band of enamel. . . . *Mastodon andium*.
    b Tusks slender, almost straight, and without any longitudinal band of enamel. . . . *Mastodon platensis*.
    c Tusks very thick, without any band of enamel and completely straight, or almost straight for their entire length. . . . *Mastodon rectus*.
  B Height two-fifths less than that of the preceding group. Tusks [long], slender, almost straight, not twisted in a spiral, and with a broad longitudinal band of enamel. . . . *Mastodon argentinus*.

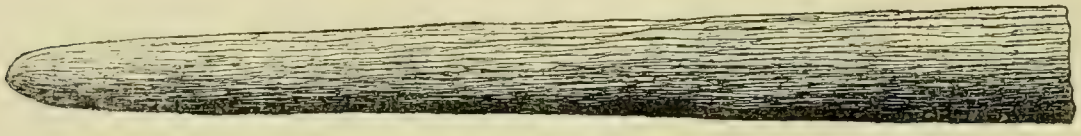
II Transverse crests of the molars, when worn, show a double clover-leaf pattern.[1] Height enormous.
  A Tusks very thick, extremely curved, with no band of enamel, and gradually diminishing in size from the base to the anterior extremity. . . . *Mastodon Humboldti*.
  B Tusks long, not so thick, straight in the posterior part, slightly curved in the anterior part, without any enamel band, and with the greatest thickness at about the middle of their length. . . . *Mastodon superbus*

[1]Both Ameghino (1889) and Carette (1919) distinguish '*Mastodon*' *platensis* as possessing a 'clover-leaf pattern,' i.e., *single trefoils*, as compared with '*M.*' *humboldtii* possessing a 'double clover-leaf pattern,' i.e., *double trefoils*.

Defensa de *Mastodon platensis*, Amegh. $^1/_{15}$ del tamaño natural

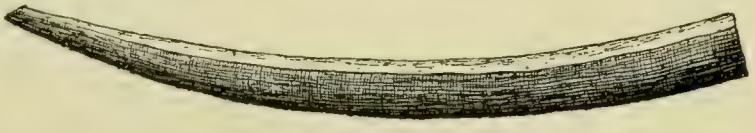
Fig. 489. Type superior tusk of *Mastodon platensis* Ameghino, 1888. After Ameghino, 1889, p. 641, one-fifteenth natural size. Original in Museo Nacional de La Plata No. 8–63. [=*Cuvieronius platensis* of the present Memoir.] Locality: San Nicolás de los Arroyos, Province of Buenos Aires, Argentina.

(Cabrera, 1929, p. 98): "*Tipo.*—Una defensa de macho adulto, procedente de San Nicolás de los Arroyos, provincia de Buenos Aires. Departamento de Paleontología del Museo de La Plata, n° 8–63 . . . . Según Ameghino (1889), el horizonte típico de *platensis* es el Belgranense, pero *rectus* y *maderianus*, que evidentemente son sinónimos suyos, corresponderían al piso Ensenadense. En términos generales, la especie puede considerarse como propia del Pampeano medio y la parte más alta del Pampeano inferior, es decir, aproximadamente lo que entiende Frenguelli (1928, pág. 73) por Prebelgranense y Belgranense."



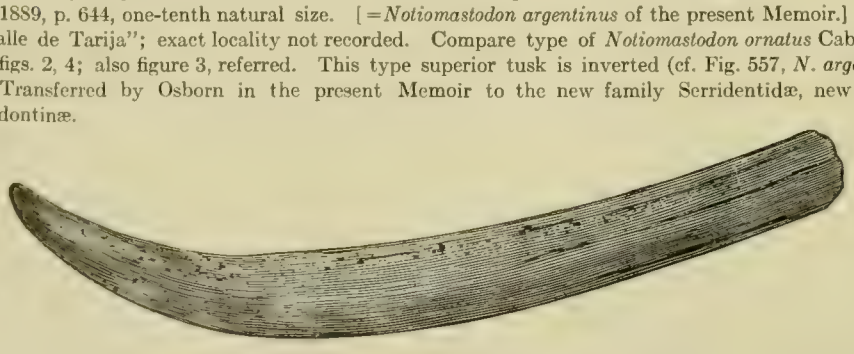
Defensa de *Mastodon rectus*, Amegh. $^1/_{13}$ del tamaño natural

Fig. 490. Type superior (?) tusk of *Mastodon rectus* Ameghino, 1889, p. 643, one-thirteenth natural size. Original in the Museo Nacional de La Plata No. 8–38. [=*Cuvieronius rectus* of the present Memoir.] Locality: La Ensenada, near La Plata, Argentina. (Cabrera, 1929, p. 99) "Dos defensas de un macho muy viejo, de La Ensenada, cerca de La Plata; tipo de *M. rectus* Ameghino (n° 8–38)."



Defensa de *Mastodon argentinus* $^1/_{10}$ del tamaño natural

Fig. 491. Type superior tusk of *Mastodon argentinus* Ameghino, 1888, with broad enamel band. After Ameghino, 1889, p. 644, one-tenth natural size. [=*Notiomastodon argentinus* of the present Memoir.] Locality: "Salta y Valle de Tarija"; exact locality not recorded. Compare type of *Notiomastodon ornatus* Cabrera, 1929, pp. 91, 92, figs. 2, 4; also figure 3, referred. This type superior tusk is inverted (cf. Fig. 557, *N. argentinus*, *N. ornatus*). Transferred by Osborn in the present Memoir to the new family Serridentidæ, new subfamily Notiomastodontinæ.



Defensa del *Mastodon superbus*, Amegh, $^1/_{20}$ del tamaño natural

Fig. 492. Type superior tusk of *Mastodon superbus* Ameghino, 1888. After Ameghino, 1889, p. 647, one-twentieth natural size. Original in Museo Nacional de La Plata No. 8–8. [=*Cuvieronius superbus* of the present Memoir.]

(Cabrera, 1929, p. 120): "*Tipo.*—Un par de defensas y la mandíbula de un ejemplar muy viejo, con los m^3 [M_3] muy usados, de Pergamino, provincia de Buenos Aires. Departamento de Paleontología del Museo de La Plata, n° 8–8. . . . Pleistoceno superior. Ameghino atribuyó la especie a su piso Lujanense, o Pampeano lacustre, y bajo el nombre de *M. Humboldti* la ubicó en el Bonaerense y el Lujanense."

Boule (1920, pp. 67, 68) adopts Ameghino's classification without question, namely:

I. "Molaires . . . d'un seul trèfle": *Mastodon andium, M. platensis, M. rectus, M. argentinus.*
II. "Molaires . . . d'un double trèfle": *Mastodon humboldtii, M. superbus.*

Osborn, 1925: It is very important to note from the above synopses that Section I includes four species to which are attributed molar teeth with *single* trefoils but otherwise distinguished by very profound differences in the form of the tusks and in the presence or absence of the enamel band: that Section II includes two species with *double* trefoils and tusks without enamel band.

On examining Ameghino's detailed description of *Mastodon andium* (*op. cit.*, 1889, pp. 639, 640), of *M. platensis* (pp. 641–643), of *M. rectus* (pp. 643, 644), and of *M. argentinus* (pp. 644, 645), it appears that the type specimens in each case are the tusks and that the grinding teeth (in the case of *M. rectus*) may belong to another specimen; in the case of *M. platensis* the type is a complete tusk of an adult individual (*op. cit.*, 1889, p. 641) to which Ameghino referred the skull of a young individual. There are no illustrations of the grinding teeth, excepting the figure of *M. rectus* Ameghino (Fig. 546),[1] and, so far as we understand, Ameghino's diagnosis (as copied by Boule) rests not on *type* specimens alone, but on characters derived from both type and *referred* specimens. Consequently Osborn (1926) does not accept the Ameghino-Boule classification, but adopts a binary division into:

I. *Mastodon humboldtii* group (=*Cuvieronius*), with double[2] trefoils, tusks rounded, without enamel band.

II. *Mastodon andium* group (=*Cordillerion*), with single[2] trefoils, tusks oval, with enamel band.

Osborn's binary division, elaborated below in the present Memoir, is naturally subject to further research on the type and referred materials employed by Ameghino. Osborn (1933) adopts a further subdivision into five groups (I–V) as defined on page 541. See also synopsis (1934) at close of this chapter (p. 615).

Consequently all the specific names of Ameghino are retained in this Memoir, while the generic names adopted by him are altered, as shown in the table "Order of Discovery and Description" below (p. 537).

Fig. 493. Ameghino's schema of the phyletic relations of species of South American proboscideans. After Ameghino, 1889, p. 652.

We observe that this phylogenetic scheme of Ameghino differs widely from that of Osborn adopted in the present Memoir, in which the species attributed to *Cordillerion* (i.e., *Mastodon tarijensis, M. andium*) are separated generically from those attributed to *Cuvieronius* (i.e., *M. rectus, M. platensis, M. superbus, M. humboldtii*).

The original definitions of these new species are cited above and in their respective descriptions below. Since the type material consists of superior tusks only and does not include the grinding teeth, it is difficult to determine whether all the species of Ameghino are new or whether they are in part synonyms of the previously described *'Mastodon' andium* or *'M.' humboldtii.*

[1]Subsequent to this note are the admirable figures of Cabrera in his Memoir of 1929, several of which are reproduced in Sec. II, 6, of the present chapter.

[2](Burmeister, 1889, p. 41, translation): The strikingly larger grinders of *M. humboldtii* are as a rule of lighter color, the dentine is white or light yellow, and the somewhat thicker enamel layer is of a brownish color. Moreover, the number of transverse crests in teeth, chiefly of the same age, is the same in both species. Gervais made the striking observation, as a positive distinction between the two species, that the worn larger cones of each ridge-crest in *M. andium* exhibit only one trefoil on each side, whereas in *M. humboldtii* two trefoils are observed; but this rule is not without exceptions; I find here and there, especially in upper grinders, also two trefoils in *M. andium*, although I allow that the famous observation of Gervais holds in the greater number of grinders.

Two New Species Proposed by Philippi in 1893

Of certain of Ameghino's species Philippi observes (Zeits. deutsch. geol. Ges., XLV, 1893, p. 88):

> Ameghino unterscheidet in seinem oben citirten Werk hauptsächlich nach den Stosszähnen sechs südamerikanische Arten von *Mastodon:* 1. *M. andium*, sehr leicht an den spiralförmigen Stosszähnen zu erkennen, die einen Streifen Schmelz haben; 2. *M. platensis* mit langen, dünnen, fast geraden Stosszähnen, und weit kleiner als die übrigen Arten; 3. *M. rectus* mit geraden, sehr dicken Stosszähnen; 4. *M. argentinus* mit kurzen, dünnen, fast geraden Stosszähnen; 5. *M. Humboldti* mit sehr dicken und sehr stark gekrümmten Stosszähnen; 6. *M. superbus* mit weniger dicken, hinten geraden und erst in der vorderen Hälfte etwas gekrümmten Stosszähnen. . . . . Ist dies [i.e., *M. chilensis*] eine der sechs Ameghino'schen Arten? Wichtig zur Artbestimmung ist das Stück Stosszahn und das Kinn. Der Stosszahn beweist, dass die Knochen weder dem *M. andium*, noch *M. platensis*, *M. argentinus*, *M. rectus* oder *M. Humboldti* angehört haben, aber auch nicht dem *M. superbus*, denn Ameghino's Beschreibung der Stosszähne passt nicht, ebenso nicht das Kinn. Leider fehlt die Abbildung desselben. Bei der Gelegenheit will ich erwähnen, dass ich das chilenische *Mastodon* für eine eigene Art halten muss, die ich *M. chilensis* nenne.

As shown in the table below, the two species described by Philippi in 1893 are referred generically in the present Memoir as follows:

Mastodon chilensis Philippi, 1893	=*Cuvieronius chilensis*
Mastodon bolivianus Philippi, 1893	=*Cordillerion bolivianus*

The Rostrum.—These two species are clearly distinguished from each other, as shown in the type illustrations (Fig. 547, p. 582), by the characters of the rostrum of the jaw. Philippi (1893, p. 90) observes:

> "Das von mir abgebildete Kinn, dessen Oberseite sehr abgeblättert ist und keine Spur der erwähnten Kanten mehr zeigt, wurde im Jahre 1877 von meinem Sohn bei Chillan nebst Beinknochen etc. ausgegraben; es waren dabei sämmtliche acht Backenzähne, von denen zwei gestohlen sind, und beide Stosszähne, die aber bis auf die Spitzen in winzige Fragmente zerfielen; die Schädelknochen waren zu Mulm zerfallen."

Revision by Erland Nordenskiöld, 1903, see Figure 507

The important paper of Nordenskiöld, entitled "Über die Säugetierfossilien des Tarijatals, Südamerika. I. Mastodon Andium Cuv.," 1903, contains a large number of original observations of value which may be summarized in the author's own language by a rearrangement of the paragraphs on pages 23 and 24:

> [Common Characters of the Notorostrines].—Die südamerikanischen Mastodonten sind, wenn man sie mit ihren europäischen Verwandten vergleicht, in gewissen Beziehungen ganz spezialisiert: es fehlen ihnen die Prämolaren, die benutzte Zahnfläche umfasst nur 1⅓–1½ Zahn, sie haben höchst unbedeutende Stosszähne im Unterkiefer,—alles Charaktere, welche die geologisch jüngeren Mastodonten charakterisieren; sie sind dagegen kaum Tetralophodonten, sie haben im allgemeinen Schmelzbänder an den Stosszähnen, Charaktere, die ja mehr den geologisch älteren Mastodontenformen eigen sind. Man sieht somit hier, dass die südamerikanischen Mastodonten in einigen Eigenschaften mehr spezialisiert waren, in anderen zurückgeblieben sind, doch darf nicht vergessen werden, dass die europäischen Formen untereinander eine grosse Ungleichheit im Wechsel der auf eine Spezialisierung hindeutenden Charaktere darbieten.
>
> [Geologic Distribution].—*Offenbar können wir jedoch in Südamerika innerhalb der Gattung Mastodon wenigstens zwei Variationscentra, eines, von dem wir zahlreiche Reste in den Anden (Tarijatal) haben, und eines, von dem wir reiche Überbleibsel um Buenos-Ayres, in Uruguay und in den angrenzenden Gegenden finden, unterscheiden.* Diese beiden Variationscentra, *Mastodon andium* und *Mastodon Humboldti*, welche jedenfalls aus derselben Form hervorgegangen waren, sind in ihren extremen Variationen weit verschieden, sie können aber auch wahrscheinlich so gut wie zusammenfallen, und man kann z. B. nicht mit Sicherheit bestimmen, ob der einzelne Zahn der einen oder der anderen Form angehört, sondern man kann sie erst mit Hülfe eines grösseren, das Variationsgebiet der Form deutlich veranschaulichenden Materials unterscheiden.
>
> [Distinctions, M. andium, M. humboldtii].—Sie unterscheiden sich folgendermassen. *Mastodon andium* ist kleiner, hat längere, gekrümmte Stosszähne mit deutlichem Schmelzband, während die Stosszähne von *Mastodon Humboldti* kurz, dick und mit undeutlicherem Schmelzband versehen sind. Die Symphyse des Unterkiefers ist bei *M. andium* weniger nach unten gebogen,

länger als bei *M. Humboldti*, die gleichzeitig benutzte Kaufläche derselben ist etwas kleiner, die Zähne haben im allgemeinen einfache Treffe, während *M. Humboldti* doppelte hat. *M. andium* würde eine grössere Tendenz, als die andere Form, zum Übergang aus dem trilophodonten in das tetralophodonte Stadium zeigen. Die Frage, ob man diese für Arten halten soll oder nicht, will ich dahin beantworten, dass sie wahrscheinlich geographische Arten gewesen sind, d. h. Arten, entstanden durch topographische (geographische) Isolation.

[Relations, M. andium, M. humboldtii].—Hiergegen spricht die Verbreitung, wendet man ein. *Mastodon Humboldti* und *Mastodon andium* sind nämlich beinahe überall in Südamerika durcheinander erwähnt. Dies beruht wahrscheinlich darauf, dass man aus anderen Gegenden, als Buenos-Ayres und Tarija, nur ein so unbedeutendes Material beschrieben hat, dass man die Variation der Spezialisierung nicht hat berücksichtigen können, ein Faktor, der bei der Bestimmung dieser Formen notwendig ist.

[Sexual Characters, M. andium, M. humboldtii].—Fasse ich hier die mit Bezug auf die individuelle Variation der südamerikanischen Mastodonten behandelten Charaktere zusammen, um zum Verständnis der dort vorkommenden Formen beizutragen, so sehen wir, dass die von Philippi durch die Form der Symphyse unterschiedenen Arten nach Charakteren aufgestellt sind, die beim Mastodon von Tarija mit dem Geschlecht variieren, und dass die nach der Form der Stosszähne und der Grösse des Schmelzbandes aufgestellten Arten nach weniger variablen Charakteren aufgestellt und vor allem ausführlicher beschrieben werden müssen.

[Chile, Brazil, Mexico].—Interessant wäre es, eine nähere Beschreibung der in Chile gefundenen Mastodontenreste zu erhalten. Nach den Abgüssen, die ich aus Tagua-Tagua in Chile gesehen habe, scheint mir dort eine Lokalrasse gelebt zu haben, deren Grösse und Stosszähne wie die des *Mastodon Humboldti* waren, dessen Zähne mehr denen des *Mastodon andium* geglichen haben—eine Frage, die nur durch ein grösseres Material ins Reine gebracht werden kann. Auch eine Beschreibung der in Brasilien gefundenen Mastodontenreste, von denen sich jedenfalls ein grosses Material in Rio de Janeiro findet, würde wahrscheinlich zeigen, dass dort eine besondere Lokalform gelebt hat. Besonders wichtig wäre es, eine Beschreibung der in Centralamerika und Mexiko gefundenen Reste zu erhalten. Ein schöner Unterkiefer von dort ist von Meyer [1867] beschrieben, einige Zähne befinden sich in Hamburg und London. In amerikanischen Museen dürfte sich jedenfalls ein reiches Material befinden

Nordenskiöld's Summary of Distinctions

Mastodon andium Group	Mastodon humboldti Group
1. Animals of smaller size; tusks relatively longer, spirally formed, with broad enamel band.	1. Animals of larger size; tusks relatively shorter, thicker, with reduced or invisible enamel band.
2. Mandibular symphysis longer, less bent downwards.	2. Symphysis shorter, more bent downwards.
3. Grinders with single trefoils.	3. Grinders with double trefoils.
4. Tendency towards transition from trilophodont to tetralophodont intermediate molars.	4. Fully attained intermediate molars.
5. Form of symphysis varying with the sex; tusks more slender in females.	5. Tusks upturned.
[= *Cordillerion andium*]	[= *Cuvieronius humboldtii*]

Revision by Eduardo Carette, 1919, see Figures 531, 532

Eduardo Carette's summary (p. 173) of the species of Cuvier, Ameghino, and Philippi, together with his conclusions (p. 178) as to their taxonomic validity, is as follows:

1° *Mastodon andium* Cuv.: esta especie está caracterizada por sus molares y sus incisivos; las *muelas* gastadas presentan figuras de trébol solamente en una de las dos columnas de cada serie transversal, que es la interna en los dientes superiores y la externa en los inferiores; las otras columnas muestran figuras piriformes o en losange, sencillas; los molares intermedios (M_2) tienen una tendencia manifiesta a la tetralofodontia, pero típicamente son trilofodontes. En las *defensas* de unos dos metros de largo, es peculiar la faja de esmalte que las recorre hasta la extremidad distal, y la forma de la doble curvatura que responde al mismo aspecto de la faja de esmalte.

Se han encontrado restos de esa especie en Chile, Perú, Ecuador, Bolivia y, más al norte, hasta Centro América.

2° *M. platensis* Amegh., 1888: parece presentar en los *molares* la misma tendencia que *M. andium* a la tetralofodontia; y en ellos se forman igualmente figuras de trébol sencillo y otras en losange. La mayor diferencia entre las dos especies reside en la forma no espiralada de las *defensas* y la completa ausencia de la faja longitudinal de esmalte; en cuanto a dimensiones, coincidirían más o menos.

Sus restos proceden de la provincia de Buenos Aires.

3° *M. rectus* Amegh., 1889: los fragmentos de *muelas* que dice haber visto el doctor Ameghino, habrían sido del tipo de *M. andium;* las *defensas*, en cambio, como en *M. platensis*, carecen de faja de esmalte y no indican torsión en espiral; pero son casi rectas y en diámetro y longitud sobrepasan quizá en algo a las de esa especie.

Tambien provienen sus restos de la provincia de Buenos Aires.

4° *M. maderianus* Amegh., 1891: nada se sabe de sus *molares*, pero sus *defensas* casi rectas, son parecidas a las de *M. platensis*, de las que difieren por su mayor tamaño y por poseer una faja de esmalte lateral en todo el largo. Procede del mismo lugar que la anterior.

5° *M. argentinus* Amegh., 1888: esta especie se diferenciaría de todas las otras por su pequeño tamaño; sus *muelas* corresponden al tipo *Andium*, pero las *defensas*, la mitad más pequeñas que las de *M. platensis* y, con las cuales parecen coincidir en forma general, están provistas de una faja de esmalte en la cara superior.

Su procedencia, bastante dudosa, sería la provincia de Catamarca.

6° *M. Humboldti* Cuv.: esta especie, que puede alcanzar un gran tamaño, se diferencia de *M. andium* y afines por las figuras de trébol, a veces complicadas, que por el desgaste se producen a la vez en ambas columnas, interna y externa de los *molares* superiores e inferiores; pero es de advertir que las internas de los primeros y las externas de los últimos, son más definidas que las otras. Por lo demás, siempre se ve una tendencia, cuando menos, a la disposición alternada en las series de conos. Las *defensas* en esta especie, son ordinariamente de mayor tamaño que en *M. andium*, sobre todo mucho más robustas y más encorvadas; no llevan faja de esmalte alguno.

La dispersión de *M. Humboldti*, además de la Argentina, alcanza el Uruguay, Paraguay, Brasil, Colombia y quizá Méjico.

7° *M. superbus* Amegh., 1888: el doctor Ameghino le atribuye grandes *molares* del tipo *Humboldti* con mamelones o conos semialternantes, con figuras de trébol menos marcadas, pero con el esmalte muy replegado. Sus *defensas*, sin rastro de esmalte, son más largas, pero menos gruesas y menos encorvadas.

El tamaño de *superbus* sobrepasaría a *M. Humboldti* y se habría extendido por Buenos Aires y Santa Fe.

Antes de pasar más adelante, tengo que añadir que el naturalista chileno doctor Philippi, no pudiendo referir ciertos restos de Mastodontes a una u otra de las descripciones del doctor Ameghino, creó en 1893 para la región trasandina, dos nuevos tipos (*M. chilensis* y *M. bolivianus*) fundándose en la morfología de la sínfisis mandibular. Sus diagnosis son enteramente breves y se podrían acercar las dos especies a ambos grupos dibelodontinos platenses. En 1905 Pompeckj amplió el estudio de Philippi sobre *M. bolivianus*, el que ofreciendo grandes semejanzas con *M. andium*, se apartaría de él por detalles en la forma de la mandíbula, principalmente en cuanto a la configuración de la parte sinfisaria. . . .

En conclusión, las especies argentinas admisibles en el grupo Dibelodonte, serían:

1° *D. andium* (Cuv.): tal como viene caracterizado por los autores con sus defensas en espiral, faja de esmalte igualmente espiralada, y molares tri-tetralofodontes con figuras de trébol unilaterales;

2° *D. platensis* (Amegh.) (1): de defensas en un solo plano horizontal, de tamaño semejante a *D. andium*, con muelas de tipo intermedio ordinariamente sin faja de esmalte en las defensas. En esta especie incluiría al *M. argentinus*, *M. maderianus* y *M. rectus* (?) que no considero, hoy por hoy, suficientemente caracterizados;

3° *D. Humboldti* (Cuv.): de defensas encorvadas hacia arriba, muy robustas, los molares ordinariamente con figuras de trébol dobles y bilaterales. A *D. Humboldti* se une *M. superbus* Amegh. que representa individuos de mayor tamaño, quizá el sexo masculino de la especie.

Creo que además hay que reconocer otra especie, cuyo material osteológico describiré detalladamente en otro lugar; a ella pertenecería un pequeño cráneo joven, que el doctor Ameghino ha atribuído a la *M. platensis*, 1888, fuera de otros restos de adultos de las colecciones del Museo de La Plata.

The above review of Carette is followed in Sec. II, 4 and 5, of the present chapter by a review of Dr. Franz Spillmann's discoveries in Bolivia and Ecuador, and in Sec. II, 6, by a synopsis of Dr. Ángel Cabrera's revision of 1929.

4. DISCOVERY OF MEXICAN AND NORTH AMERICAN SPECIES. PHYLOGENETIC AND SPECIFIC REVISIONS BY COPE, LULL, AND BOULE (1884–1920)

Cope proposes the Genera Dibelodon and Tetrabelodon (1884–1889)

Cope's revision of the genera of the Proboscidea (1884.2) occurs on pages 2–8 of his paper "The Extinct Mammalia of the Valley of Mexico," read before the American Philosophical Society on May 16, 1884. In proposing the name *Dibelodon*, he discusses (p. 2) previous attempts to define as 'genera' groups of 'species' included formerly within the single genus *Mastodon* of authors, i.e., "*Mastodon* pars, auctorum."

After reviewing the generic nomenclature, based upon the number or the form of the transverse crests, that is, *number* by Falconer (e.g., *Trilophodon*, *Tetralophodon*), *form* by Vacek (e.g., *Bunolophodon*, *Zygolophodon*), Cope dismisses the Falconer-Vacek nomenclature based on either the number or the form of the ridge-crests and concludes (p. 3): "There is no doubt that the presence of a pair of persistent inferior incisors defines a genus as distinct from one in which there is not a pair of permanent inferior incisors." He accordingly selects (p. 4) the Greek word *Dibelodon*, signifying δί-, two, βέλος, dart, ὀδούς, tooth, and proceeds to define two new genera, *Dibelodon* and *Tetrabelodon*, as follows:

> *Dibelodon* Cope. Superior incisors with enamel band; inferior incisors wanting. Type *D. shepardi* [=*Rhynchotherium shepardi* of the present Memoir].
>
> *Tetrabelodon* Cope. Superior incisors with enamel band; inferior incisors present in the male at least. Type *T. angustidens* [=*Trilophodon angustidens* of the present Memoir].

Cope's new generic name *Dibelodon* (signifying 'two-tusker'), although subsequently applied by all American authors to the South American species, unfortunately cannot be used, because it was based upon the genotypic species *Mastodon shepardi* of Leidy, a 'four-tusker' of the genus *Rhynchotherium* Falconer. *Dibelodon* Cope (1884), therefore, is a synonym of *Rhynchotherium* Falconer (1856, 1863, 1868).

Osborn, 1926: (1) Cope's generic name *Tetrabelodon*, while correctly defined, must be dismissed as a synonym of *Trilophodon* Falconer. (2) Cope's name *Dibelodon* is incorrectly defined, since it is certain that inferior incisors were present in the genotypic species '*M.*' *shepardi*. (3) The name *Dibelodon* moreover must be regarded as a synonym of *Rhynchotherium* Falconer, because the type of '*M.*' *shepardi* Leidy belongs to *Rhynchotherium*. (4) Cope (1884.2, p. 5) continues his unfortunate errors by referring a jumble of species to his two invalid new genera, namely:

> *Dibelodon shepardi* Leidy, California, Mexico. [Genotypic species = *Rhynchotherium shepardi* of the present Memoir.]
>
> *Dibelodon tropicus* Cope, Tropical America. [Referred species = *Cordillerion tropicus* of the present Memoir.]
>
> *Dibelodon humboldtii* Cuv., South America. [Referred species = *Cuvieronius humboldtii* of the present Memoir.]
>
> *Tetrabelodon angustidens* Cuv., India, Europe, N. America. [Genotypic species = *Trilophodon angustidens* of the present Memoir.]
>
> *Tetrabelodon andium* Cuv., S. America, Mexico. [Referred species = *Cordillerion andium* of the present Memoir.]
>
> *Tetrabelodon productus* Cope, SW. N. America. [Referred species = *Serridentinus productus* of the present Memoir.]

In 1889 Cope (1889.2, p. 195) listed four species under his new genus *Dibelodon* as follows, indicating by a "*p*" the species in which the condition of the premolars is unknown.

> *Dibelodon shepardi* Leidy. California, Mexico. *p.* [=*Rhynchotherium shepardi* of the present Memoir.]
>
> *Dibelodon cordillerarum* Desm. . . . South America. [=*Cordillerion andium* of the present Memoir.]
>
> *Dibelodon tropicus* Cope. . . South America and Mexico. *p.* [=*Cordillerion tropicus* of the present Memoir.]
>
> *Dibelodon humboldtii* Cuv. S. America. [=*Cuvieronius humboldtii* of the present Memoir.]

Lull Adopts Cope's Erroneous Revision and Nomenclature

Lull, 1908, 1909.—In 1908 Lull accepted Cope's revision and nomenclature of the South American mastodonts in his article "The Evolution of the Elephant" (reprinted after author's revision in 1909). His text may be abstracted as follows:

Lull, 1908, pp. 21–23

Tetrabelodon [=*Trilophodon, Serridentinus*]

The mastodons have been divided in two ways, one depending upon the number of ridges borne upon the grinders, while the other classification is based upon the number and character of the tusks. The latter seems the more logical from a developmental viewpoint. The first of these genera is *Tetrabelodon*, with four, enamel-banded tusks. The second is *Dibelodon*, having but two tusks which still retain the band of enamel. . . . *Tetrabelodon* was a widely spread, migratory form, for we find species referable to this genus not only in Europe but in Africa, Asia, and in North America. In Eurasia it gave rise to *Mammut* through the loss of the lower tusks and the enamel band, while in America there arose *Dibelodon*, which retained the enamel band and which was the first proboscidian to reach South America after the formation of the Central American land connection either late in the Miocene or in the early Pliocene. The Yale Museum contains fine specimens of teeth and tusks of *Tetrabelodon angustidens* from France as well as similar remains of *Tetrabelodon proavus*, *T. campester*, *T. productus*, and *T. serridens*. In the Yale Museum is also preserved part of the holotype of *Tetrabelodon shepardi* Leidy from California, of which the remainder is in the museum of Amherst College.

Lull, 1908, p. 23

Dibelodon [=*Cordillerion, Cuvieronius*]

The genus *Dibelodon* is known principally from the jaws, teeth and tusks, though two splendid skulls of *D. andium* are preserved in the Museo Nacional in Buenos Aires. The upper tusks are well developed, displaying an elongated spiral form, with a well developed enamel band, but the lower jaw is quite short though the symphysis is longer and more trough-like than in the genera *Mammut* and *Elephas*. The lower tusks have entirely disappeared and with the shortening of the jaw the trunk must have become pendant as in the modern elephants. The genus *Dibelodon* contains several species, among which are *Dibelodon humboldii* (Cuvier), *D. mirificum* (Leidy), *D. præcursor* (Cope), and *D. andium* (Cuvier). Of these *Dibelodon humboldii* and *D. andium* ranged into South America and were in fact almost the only proboscidians to cross into the southern hemisphere of the New World. Some of these animals lived in the high Andes at an elevation of 12,350 feet above the level of the sea, at a time when the region had a greater rainfall than now and therefore a richer vegetation.

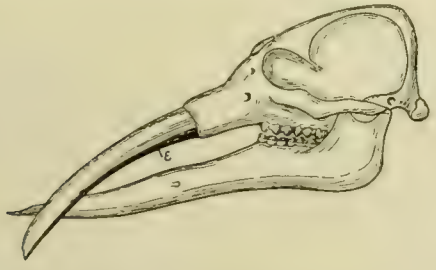


Fig. 16. Skull of *Tetrabelodon angustidens*.

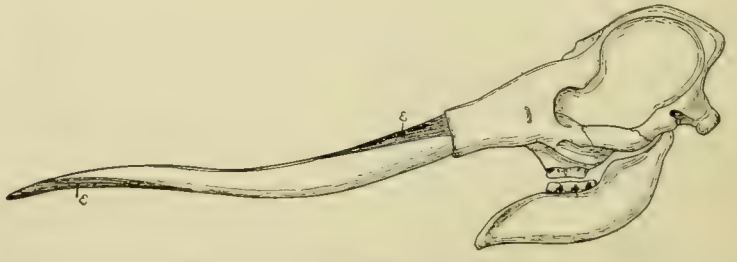


Fig. 18. Skull of *Dibelodon andium*.

Fig. 494. Crania of *Tetrabelodon* [=*Trilophodon*] *angustidens* (Fig. 16) and of *Dibelodon* [=*Cordillerion*] *andium* (Fig. 18), as figured and contrasted by Lull. After Lull, 1908, figs. 16 and 18.

Osborn, 1924: It will be observed, in dissenting from Lull, that (1) within the above description of *Tetrabelodon* is included the species *'Tetrabelodon' shepardi* Leidy which Cope selected as the genotypic species of *Dibelodon;* (2) in the above characterization of *Dibelodon* are included the species *D. humboldii*, *D. andium*, and others; (3) *Dibelodon* would have been a most appropriate name for the species *Mastodon andium* and *M. humboldtii*, if Cope had not founded the genus on the four-tusker *Mastodon shepardi*.

Phylogeny (Lull, 1908, pp. 34–36; 1909, pp. 667–670).—Lull proposes a new American phylogeny of the Proboscidea (1908, p. 34):

The earliest North American form, *Tetrabelodon productus*, resembled its European prototype [i.e., *Trilophodon angustidens*] very closely and gave rise to a remarkable group of four-tusked mastodons which ranged from Nebraska to Florida. From some of the later species arose the *Dibelodon* race with upper, enamel banded tusks, but lacking those of the lower jaw. This genus is reported from the Pliocene (Blanco) of Texas and Mexico and ranges as far south as Buenos Aires in the southern hemisphere. Two South American species are known to us, one, *D. andium*, following the chain of the Andes as far south as Chili. This type is often found at great altitudes, a specimen from the Quito valley in Ecuador, now in the Yale collection, having been found 10,000 feet above the level of the sea.

Dibelodon humboldii was a dweller on the plains, being found in the pampas formation near Buenos Aires, while Darwin records it along the banks of the Parana River in Argentine, and Wallace reports the same species among other remains in a limestone cavern near the headwaters of the San Francisco river in southern Brazil. *D. humboldii*, like *D. andium*, has its origin in the Texas Pliocene, the line of migrations nearly paralleling, the one along the tropical plains, the other along the Andine plateau as far south as northern Chili. With the exception of a lone specimen of *Elephas* reported from French Guiana and the mastodon of Honduras, *Dibelodon* is the only proboscidian of the Neotropical realm. [Since Lull's article of 1908 the species *Serridentinus guatemalensis* Osborn has been added to the fauna of Central America.] The migration of these great forms occurred in the late Pliocene, and for some reason, evidently climatic and vegetative, the route has been closed ever since. Otherwise it is reasonable to suppose that the elephants and mastodons of the Pleistocene would have spread into South America as well. [The "lone specimen of *Elephas* reported from French Guiana" is *Parelephas columbi cayennensis* Osborn, type.]

Lull treats the Eurasiatic phylogeny of the Proboscidea (1908, p. 36; 1909, p. 670) as follows:

In Europe *Tetrabelodon angustidens* had successors in *T. longirostris* and *arvernensis*, the latter ranging over western Europe into England. It did not, however, cross the Pyrenees into Spain. *T. longirostris* and a late mutation of *T. angustidens*, *palæindicus*, made the long journey to the Orient, transferring the evolution from Europe to India. The path of this migration is as yet unknown, as little or no paleontological exploration has been made in the region lying between Armenia on the west, across Persia, Afghanistan, and Beluchistan to the Indus River. This oriental migration must have occurred during the Upper Miocene and was followed by a relatively rapid evolution involving a number of species of mastodons and elephants. *Tetrabelodon longirostris* seems to have given rise to *Mammut* [Footnote: 'These Indian forms agree probably with the American mastodon in having but one pair of enamelless tusks. They may represent the *Mammut* stage but in an entirely different phylum, hence should not bear the same generic name.'] *cautleyi* with a shortened lower jaw, thence through *M. latidens* to *Stegodon clifti*, the transitional form between the mastodons and the elephants. *S. clifti* was followed in succession by *Stegodon bombifrons* and *S. insignis* and finally by the genus *Elephas* itself. *Elephas* proved to be a great migrant, although the stegodont species had spread from their original homes in the sub-Himalayan region eastward through Burma, China, and Japan, and perhaps as far as Java. *Elephas* later traveled in two directions, westward back to Europe and Africa, and eastward, thousands of miles, into the United States.

Evidence seems to point to an interesting parallelism in evolution between the American elephants and those of Europe, though they were undoubtedly derived from a common ancestry.

Osborn, 1926: The above phylogenies of Lull (American and Eurasiatic) are in large part based on the relatively *monophyletic* and *diphyletic* conceptions which prevail in the writings of Gaudry, Cope, Schlesinger, Soergel, and practically all other palæontologic writers, as based on the older and less exact researches and comparisons of types, and prior to the more intensive examinations of the present author for this Memoir. With the close examinations of the more recent European Proboscidea by Depéret and those of all the Proboscidea of the world by Osborn, there has been reached in the present Memoir a complete *polyphyletic* system which replaces all the older relatively monophyletic or diphyletic phylogenies.

Marcellin Boule's Revision of 1920

The most recent revision of *Mastodon andium* and *Mastodon humboldtii* is that of Boule (1920, pp. 17–74) in his invaluable Memoir entitled "Mammifères Fossiles de Tarija," in which he was aided by the superb materials of *M. andium* presented by the Marquis de Créqui-Montfort, including twelve skulls, thirty mandibles, fifty tusks, and three hundred isolated molars; he gives a masterly review of the characters of *M. andium* in comparison with *M. humboldtii* and *Elephas indicus*, including the mideranial sections here reproduced in figure 495. A summary of his detailed observations on the species *M. andium* is presented below.

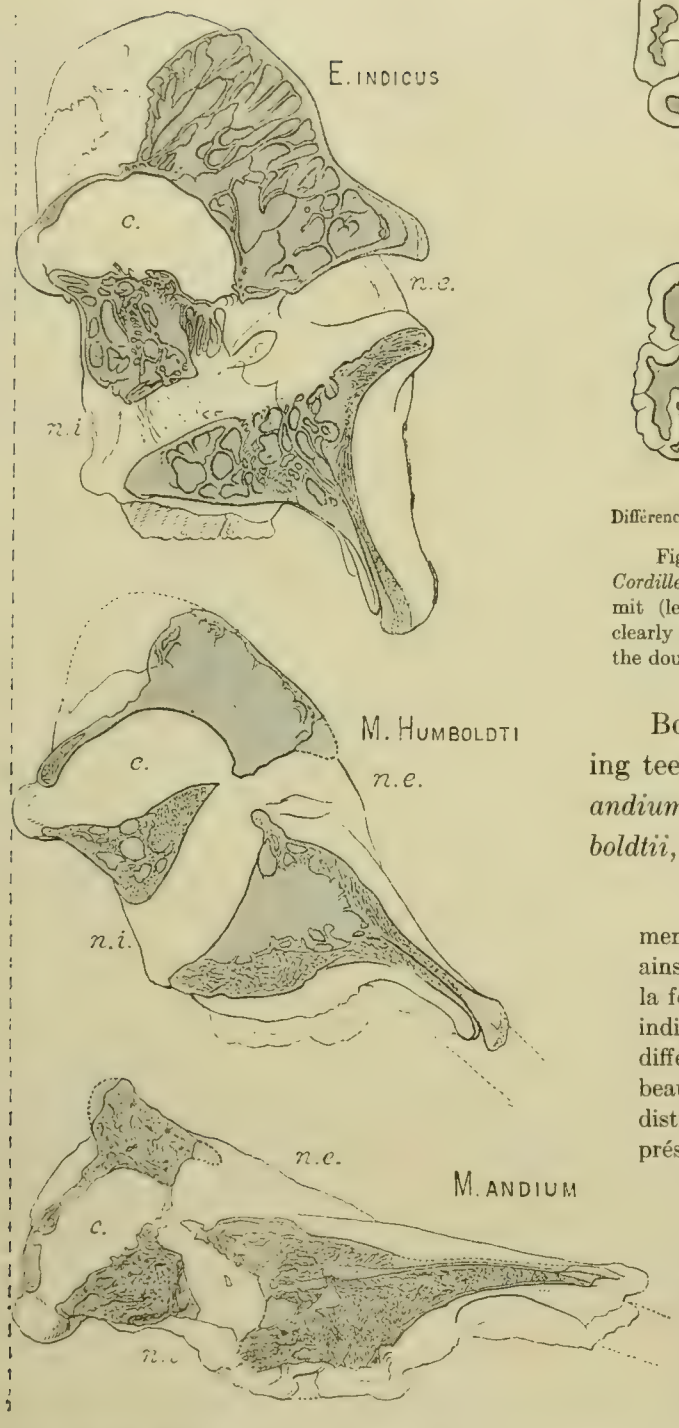


Fig. 2 à 4.
Sections, suivant le plan sagittal médian, de trois crânes de Proboscidiens : *Mastodon andium*, *M. Humboldti*. *Elephas indicus*. — 1/10e de la grandeur vraie.
c., cavité cérébrale; *n. e.*, narines externes; *n. i.*, narines internes.

Fig. 12.
Différences de plissement de l'émail d'un même lobe de plusieurs dents de *Mastodon andium*.

Fig. 496. Single crests and trefoils and enamel foldings of molars of *Cordillerion andium*. The same loph is sectioned at different levels from summit (left upper) to base (right lower); the single median trefoil is very clearly displayed as developed on one side of the crown only. Rudiments of the double trefoil appear. After Boule, 1920, fig. 12.

Boule, 1920, p. 42.—The distinctions of the grinding teeth of *M. andium*, also of those of varieties of *M. andium*, from those of the contemporaneous *M. humboldtii*, are described in the following passage:

> La détermination des Mastodontes est basée principalement, et forcément, sur le nombre et la forme des collines ainsi que des tubercules qui constituent ces collines. Mais la forme est sujette à d'assez larges variations, suivant les individus. Les dessins ci-joints (fig. 12) prouvent que les différences dans le plissement de l'émail sont telles que beaucoup de paléontologistes y verraient des caractères distinctifs de plusieurs espèces si les dents leur étaient présentées comme provenant de gisements différents.
>
> L'aspect des dents varie beaucoup avec leur usure. Le caractère principal des molaires de *M. andium* est qu'à chaque colline l'une des moitiés (interne aux molaires supérieures, externe aux inférieures) a la forme d'un trèfle, l'autre, la forme d'une crête, ce qui permet de distinguer le Proboscidien que nous étudions de son congénère, contemporain et compatriote, le *Mastodon Humboldti*. Or, si ce caractère est très net sur des molaires ayant peu fonctionné, il s'efface peu à peu et les dents très usées de *M. andium* finissent par res-

Fig. 495. Midcranial sections of 'M.' andium, 'M.' humboldtii, and E. indicus, after Boule, 1920, Figures 2 to 4

Observe that this figure shows a very profound difference between the cranium of '*M.*' *andium* [=*Cordillerion*] and the cranium of '*M.*' *humboldtii* [=*Cuvieronius*], one being more platycephalic, the other more acrocephalic; this difference, however, is undoubtedly exaggerated by vertical crushing in the cranium of '*M.*' *andium*, which, in the natural condition, is probably not less elevated or acrocephalic than that of *Ocalientinus ojocaliensis* illustrated in figure 405. Compare '*M.*' *humboldtii* cranial profile (Fig. 497) with *Eubelodon morrilli* cranial profile (Fig. 576).

sembler à celles de *M. Humboldti*, qui présentent deux trèfles au lieu d'un. Les figures ci-jointes (fig. 13), représentant une série de sections horizontales successives d'une même molaire [Footnote: 'Ces sections, obtenues en usant à la meule un morceau de dent, diffèrent un peu d'ailleurs de ce que donne l'usure naturelle. Celle-ci n'est ni plane, ni horizontale comme l'usure artificielle, elle est concave et oblique vers l'avant.'], mettent en évidence ces variations d'aspect suivant le degré d'usure

The above diagram (Fig. 496) shows that while the single central trefoil prevails, there are faint rudiments of the double trefoil in certain specimens of *M. andium*.

In his chapter "Etude Comparative des Mastodontes de l'Amérique du Sud" (p. 62) Boule considers the comments of Cuvier, de Blainville, Laurillard, Gervais, Burmeister, and Nordenskiöld, reciting especially (p. 63) the résumé of Nordenskiöld.

Mastodon andium.

1. Taille moindre.
2. Défenses longues, tordues en spirale, avec une forte bande d'émail.
3. Molaires plus allongées, formant par usure un seul trèfle pour chaque colline.
4. Trilophodonte, mais avec un talon assez développé pour présenter parfois une tendance vers la forme tétralophodonte.
5. Émail généralement moins plissé.
6. Symphyse plus longue et moins arquée vers le bas.
7. Fossile surtout dans les Hauts Plateaux des Cordillères.

Mastodon Humboldti.

1. Taille plus considérable.
2. Défenses arquées, plus courtes, sans bande d'émail ou avec faible bande d'émail.
3. Molaires plus carrées, formant par usure un double trèfle pour chaque colline.
4. Trilophodonte.
5. Émail présentant généralement un aspect plus plissé, sur les molaires usées.
6. Symphyse de la mâchoire inférieure plus courte.
7. Fossile surtout dans les Pampas de Buenos-Aires et du Brésil.

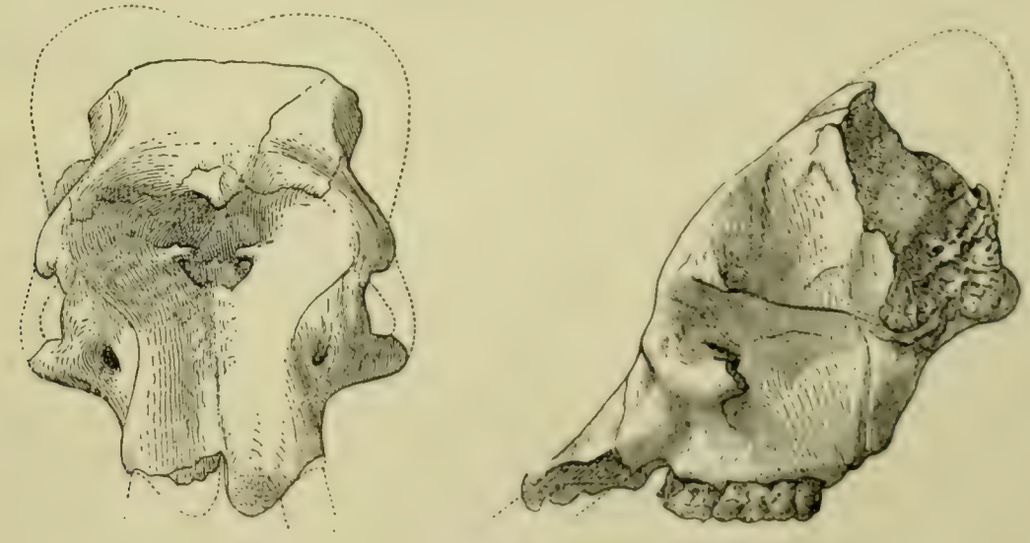


Fig. 32.

Crâne de *Mastodon Humboldti*, vu de face et de profil. (Museum national d'histoire naturelle.)
1/10e de la grandeur vraie.

Fig. 497. Cranium of *Cuvieronius humboldtii* in the Paris Museum. After Boule, 1920, fig. 32; compare crania of *C. platensis* (Fig. 563) and of *C. bonaerensis* (Fig. 542) below.

Comparing the cranium of *M. humboldtii* in the Paris Museum (Fig. 497) Boule concludes (pp. 65, 66):

On peut caractériser d'un mot la morphologie crânienne du *M. Humboldti* en disant qu'elle est beaucoup plus éléphantique, aussi bien dans son aspect extérieur que dans son architecture interne (fig. 3, p. 23 [Fig. 495 of the present Memoir]) . . . On voit que, par tous ces caractères, le *Mastodon Humboldti* est beaucoup plus évolué, plus différencié, plus perfectionné dans le sens proboscidien que le *M. andium*, dont la morphologie crânienne est encore bien voisine de celle des Mastodontes miocènes

On voit surtout que les deux espèces sont très différentes et que leur distinction sera toujours des plus faciles quand on aura des crânes entiers ou des portions importantes de crânes. Cette étude nous fournit un nouvel exemple de la nécessité où se trouvent les paléontologistes d'avoir toutes les parties du squelette des animaux dont ils cherchent à établir les affinités. Tous les auteurs qui, jusqu'à présent, ont eu à déterminer des restes de Mastodontes de l'Amérique du Sud, éprouvant de grandes difficultés à distinguer les molaires du Mastodonte des Andes des molaires du Mastodonte de Humboldt, ont pensé que ces deux espèces étaient très voisines. L'étude comparative des crânes montre au contraire qu'elles présentent des différences considérables et d'une grande importance philosophique. *M. andium* est un représentant à peine évolué des vieux Mastodontes. *M. Humboldti* est une espèce bien plus éloignée de ses origines et qui a fait de grands progrès dans une direction où les Éléphants marquent de plus grands progrès encore.

Boule then makes a larger analysis, including the species described by Ameghino, Philippi, and Pompeckj, giving a summary of his own views in tabular form (p. 67); Boule's summary, however, which divides the South American mastodonts into two sections (I and II), does not rest on his original observations, but is translated directly from the classification in Spanish on page 639 of Ameghino's Memoir of 1889:

I. Molaires dont l'usure moyenne des collines produit l'aspect d'un seul trèfle.
  A. Taille considérable:
    a. Défenses fines, peu arquées, tordues en spirale, avec bande d'émail longitudinale..... *M. andium.*
    Chili, Pérou, Équateur, Bolivie.
    b. Défenses fines, presque droites, sans bande d'émail..... *M. platensis.*
    Prov. de Buenos-Aires.
    c. Défenses plus massives, sans bande d'émail, droites ou presque droites *M. rectus.*
    La Plata, Buenos-Aires.
  B. Taille plus petite (2/5) que les espèces précédentes. Défenses courtes, fines, presque droites, non tordues en spirale, avec une bande d'émail longitudinale *M. argentinus.*
  N. O. de la République Argentine.

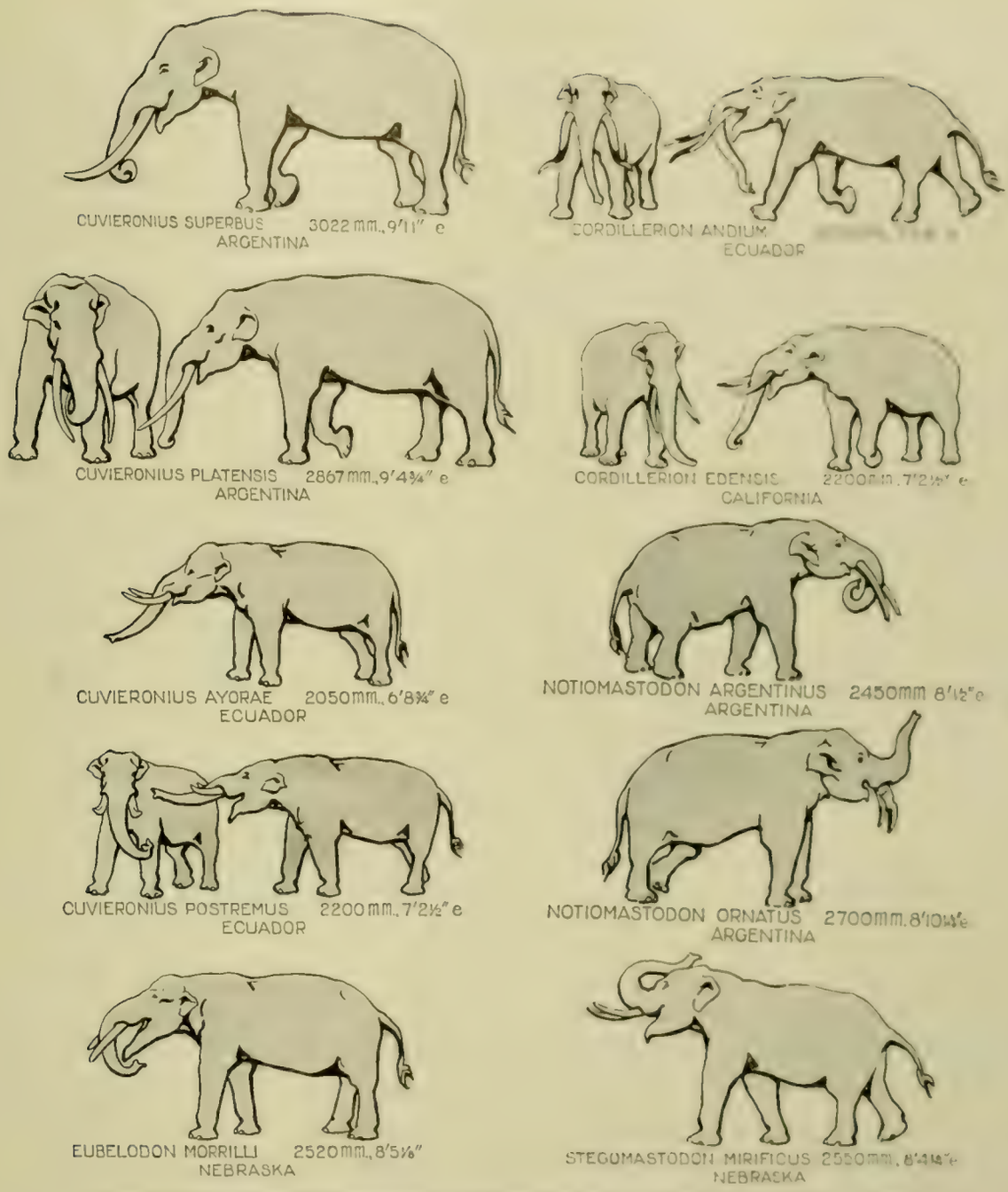
II. Molaires dont l'usure moyenne des collines produit l'aspect d'un double trèfle; pas de bande d'émail:
  a. Défenses très arquées, diminuant régulièrement de diamètre de la base à la pointe..... *M. Humboldti.*
  République Argentine, Uruguay, Paraguay, Brésil, Nouvelle-Grenade.
  b. Défenses moins arquées, avec un maximum de diamètre vers le milieu *M. superbus.*
  Sante-Fé.

Although in the above table Boule adopts Ameghino's classification without change, he regards (p. 68) the species proposed by Ameghino as representing merely individual variations, on the one hand, of *M. andium*, and, on the other, of *M. humboldtii*. Osborn (1933) does not accept the following revision by Boule (1920):

M. humboldtii Cuvier=variety or synonym, *M. platensis* Ameghino, *M. superbus* Ameghino.
M. andium Cuvier=fragmentary specimen or synonym, *M. rectus* Ameghino.
M. argentinus Ameghino=ancestral form of *M. andium*.
M. chilensis Philippi, appears to be a local race of *M. andium*.
M. bolivianus Philippi, probably a male specimen or local race of *M. andium*.

Geographic Distribution (Boule, 1920).—There follows (pp. 69, 70) a full and interesting description of the geographic distribution of these species.

M. andium and its varieties once occupied an extensive region in South America; its remains have been found in horizons of very constant lithologic character, gravels, sands, and clays, but at variable altitudes from 1,800 m. (Bolivia, i.c., Tarija) to 4,000 m. (Peru). Its remains have also been found in the Andean region of Bolivia,



RESTORATIONS OF THE NOTOROSTRINES AND HUMBOLDTINES AS KNOWN UP TO THE YEAR 1933
By Margret Flinsch, under the direction of Henry Fairfield Osborn (1933)
Uniform scale of one-hundredth

Fig. 498. The present phylogenetic grouping of these two subfamilies seems to be as below; the proposed (1934) new generic and subfamily grouping is shown in the Notorostrine and Humboldtine reclassification at the close of the present chapter (p. 615). The measurements are estimated.

'MASTODON' HUMBOLDTII GROUP

Superior tusks straight to upcurved, without enamel band.

Cuvieronius superbus, Argentina, 9 ft. 11 in.
Cuvieronius platensis, Argentina, 9 ft. 4¾ in.
Cuvieronius postremus, Ecuador, 7 ft. 2½ in.
Cuvieronius ayoræ, Ecuador, 6 ft. 8¾ in.

EUBELODON MORRILLI GROUP

Superior tusks straight, without enamel band. Inferior mandible pointed, without tusks.

Eubelodon morrilli, Nebraska, 8 ft. 5⅛ in.

STEGOMASTODON MIRIFICUS GROUP

Superior tusks upcurved, without enamel band.

Stegomastodon mirificus, Nebraska, 8 ft. 4¼ in.., described in Chapter XIII.

'MASTODON' ANDIUM GROUP

Superior tusks down- and outcurved, with spiral enamel band.

Cordillerion andium, Ecuador, 7 ft. 2½ in.
Cordillerion edensis, California, 7 ft. 2½ in.

NOTIOMASTODON ARGENTINUS GROUP

Superior tusks downcurved, with broad enamel band.

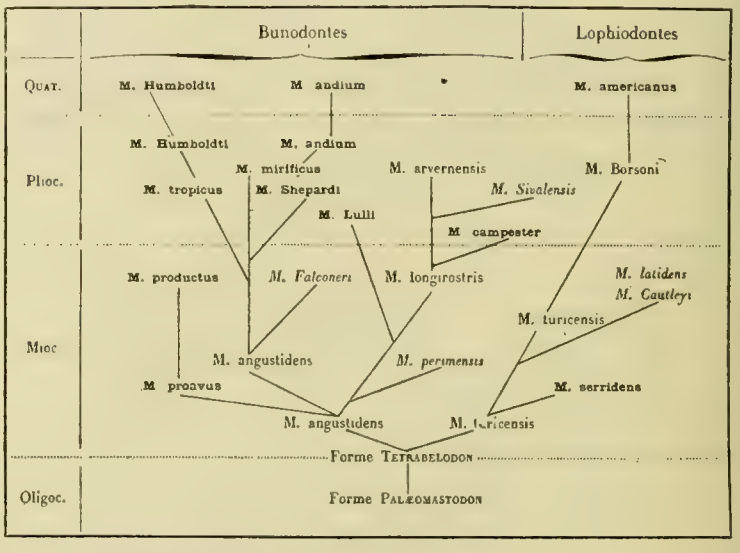
Notiomastodon argentinus, Argentina, 8 ft. ½ in.
Notiomastodon ornatus, Argentina, 8 ft. 10¼ in.

(Osborn, 1934) The genus *Notiomastodon*, including the two species *Notiomastodon ornatus* and *N. argentinus*, is transferred to the Serridentinæ (see pp. 590-592 of this chapter). For final classification, see Appendix to the present Volume I, under Serridentidæ fam. nov., Notiomastodontinæ subfam. nov.

The abbreviated mandible (Pl. XII) contains no inferior tusks.

possibly in Colombia, Brazil, Chile, and Ecuador. Similar or identical forms were found by Leidy (1866 [1859, 1869]) in Honduras, by von Meyer (1867) in Michoacan, Mexico, and related forms in Texas (Cope, 1884).

M. humboldtii has an altogether different distribution; it is characteristic of the plains region, of the pampas, found chiefly in the neighborhood of Buenos Aires, but also in Brazil and Uruguay. It therefore represents the species of the lower levels, while *M. andium* is characteristic of the mountains, although this contrast is not an absolute one. The specimens attributed to this species at Tarija by Carles and Ameghino do not belong to it; at Tarija there is only one species of mastodont, namely, *M. andium*. On the other hand, an important discovery near Riobamba, Ecuador, attributed to *M. andium*, belongs without doubt to *M. humboldtii*. This specimen[1] includes an almost complete skeleton of *M. humboldtii* discovered by Doctor Proaño in the valley of Chalang near Punin, province of Chimborazo, at an altitude of 2,800 m. This "Mastodonte du Chimborazo" was attributed to *M. andium*, but a single glance at the photographs convinces one that it pertains to a very fine example of *M. humboldtii*, the cranium altogether resembling that in the Museum of Natural History, Paris. It follows that *M. humboldtii* extended its habitat from the plains into the higher mountain regions, and that many remains attributed to *M. andium* may belong to this species.



Les espèces américaines sont en caractères gras, les espèces asiatiques en *italiques*, les espèces européennes en romain ordinaire.

Fig. 499. Phylogeny of the Mastodontidæ. After Boule, 1920, p. 73. Compare with the phylogeny of the Mastodontoidea of Osborn (1935) in the Appendix at the close of the present Volume I.

Phylogeny of the Mastodontidæ.—In a retrospective review of the phylogeny of the Proboscidea, Boule traces the North and South American mastodonts back to the ancestral *Palæomastodon* and presents (p. 72) his ideas of the relationships of the American species *M. serridens* [=*Serridentinus*], *M. mirificus* [=*Stegomastodon*], and *M. shepardi* [=*Rhynchotherium*] as living in Texas, California, Kansas, and Mexico, to be considered as approximately parental or ancestral to *M. andium*, with its single trefoils; all derived by Boule from *M. angustidens* [=*Trilophodon*].

On the other hand, such Lower Pliocene species as *M. campester* [=*Tetralophodon*], with its double trefoils, one might be tempted to consider as ancestral to *M. humboldtii* but for the fact that *M. campester* is wholly 'tetralophodont' while *M. humboldtii* is trilophodont. Boule finds that the *M. tropicus* Cope, 1884 [=*Cordillerion*] may be regarded as a direct ancestor of *M. humboldtii*.

Boule's phylogenetic review (in which fifteen bunomastodont species, divided into nine different genera in the present Memoir, are placed within the single genus *Mastodon*) contrasts the two species (p. 72) of *M. andium* and *M. humboldtii*:

> *M. andium*, tout en étant aussi plus évolué que les Mastodontes miocènes à quatre défenses, a gardé beaucoup plus de souvenirs de ses origines: forme surbaissée du crâne, défenses inférieures rudimentaires, molaires peu compliquées. Il représente une survivance attardée d'un vieil état de choses, tandis que son congénère et contemporain, le *M. Humboldti*, représente

[1]Spillmann (1928, 1931) made this skeleton the type of *Bunolophodon ayorœ* [=*Cuvieronius ayorœ* Osborn]; his description and type illustrations are fully set forth in Section II, 4 and 5, of this chapter.

au contraire une forme très progressive d'un groupe destiné d'ailleurs à disparaître rapidement. Cette espèce, loin d'être un simple rameau latéral, s'insérant sur le rameau de *M. andium* comme on était porté à le croire, a dû se détacher de son groupe de très bonne heure, probablement dès le Miocène supérieur.

The author concludes (p. 74, see also Fig. 499 of the present Memoir) with a contrast between the history of the Proboscidea in Europe and in America:

Tandis qu'en Asie et en Europe de nombreux Éléphants ont succédé aux Mastodontes et que, dans l'Amérique du Nord, se sont développés des Mastodontes (*M. americanus*) à molaires formées de crêtes parallèles, à défenses recourbées comme celles des Mammouths par suite d'une adaptation semblable, Mastodontes issus eux-mêmes de formes européennes plus anciennes (*M. Borsoni*), les Mastodontes à dents mamelonnées ont persisté dans l'Amérique du Sud. Par une loi assez générale de l'évolution des Vertébrés terrestres, les formes les plus primitives ont survécu dans les régions les plus tropicales, probablement à cause de la persistance d'un climat chaud et humide. Quand une période sèche est survenue, ils se sont éteints, comme se sont éteints les Chevaux et les grands Édentés.

Boule's Errors in Phylogeny. While welcoming the many new observations and new facts brought forth in Boule's Memoir of 1920, as enumerated or cited above, Osborn is unable to accept any of Boule's conclusions or theories as to the relationships or phylogeny (Fig. 499) of these animals. We observe in this phylogeny of Boule that neither family, subfamily, nor generic lines of descent are followed, but that the zygolophodont '*M.*' *turicensis* is made the stem form of one great branch designated as 'Lophiodontes,' while the bunomastodont '*M.*' *angustidens* is made the stem form of another great branch from which arise all the subfamilies of the bunomastodont molar type, namely, the Longirostrinæ, Brevirostrinæ, Rhynchorostrinæ, Notorostrinæ, and Tetralophodontinæ of the present Memoir. As bearing upon the Boule phylogeny (Fig. 499 of this Chapter), *Cordillerion andium* is erroneously derived by Boule from *Stegomastodon mirificus*, while *Curieronius humboldtii* springs from *Cordillerion tropicus* and more remotely from *Trilophodon angustidens*.

Osborn, 1927: For the reasons given herein Osborn regrets that he cannot accept the Ameghino-Boule classification, or the opinions of Boule either as to the relationships or the phylogeny of these species.

Osborn, 1933: At the close of this Volume, Osborn presents an up-to-date phylogeny of the Mastodontoidea (see Appendix).

5. THE NOTOROSTRINES FROM MEXICO DESCRIBED BY COPE (1884, 1893), FELIX (1891), VILLADA (1903), AND FREUDENBERG (1922)

The two members of the Bunomastodontidæ thus far discovered in Mexico prove to belong to two very distinct genera, namely: (a) *Rhynchotherium*, with molars exhibiting single trefoils and enamelled superior and inferior incisor teeth, and (b) *Cordillerion*, with single trefoils and with inferior incisor teeth entirely wanting. In both these genera the third superior and inferior grinding teeth, M^3-M_3, exhibit *single* trefoils: consequently it is necessary to examine the *proportions of the third upper and lower grinders* very carefully to distinguish the genus to which these grinders found in Mexico belong:

	ap.	tr.	I.
(a) Broad grinders: *Rhynchotherium browni*, single trefoils, proportions of M_3 relatively broad, e.g.	176	96	55
(b) Narrow grinders: *Cordillerion tropicus*, single trefoils, porportions of M_3 relatively long and narrow, e.g.,	188	82	44

Once familiar with these differences of proportion, we can distinguish: (b) The long narrow grinders of *Cordillerion* from the relatively broad grinders of *Rhynchotherium:* another distinction is the very sharply defined trefoils characteristic of *Cordillerion*. (a) The most certain distinction is the large inferior tusks with enamel band in *Rhynchotherium:* while the known *Rhynchotherium* grinders of Mexico are broad, those of the *Platybelodon*[1] type of Nebraska are relatively narrow.

[1]Referred in the present Memoir to the genus *Blickotherium* Frick, 1933.

1. Cope (1884.2) was the first to examine the collections in the two Museums of the City of Mexico and to recognize in "*Dibelodon shepardi*" an animal closely related to *Mastodon andium* Cuvier which he later (1893) described as *Mastodon oligobunis* [=*Cordillerion oligobunis*].

2. In 1891, J. Felix and H. Lenk in their "Uebersicht über die geologischen Verhältnisse des mexicanischen Staates Puebla" described the Proboscidea from Mexico as belonging to *Elephas primigenius* Blum., *Elephas columbi* Falc., and *Mastodon shepardi* Leidy. While following Cope in referring to *Mastodon shepardi* a mastodont with tuskless lower jaw (*op. cit.*, p. 132), Felix and Lenk (p. 133) recognized *Mastodon tropicus* Cope also *Mastodon andium*, but in the latter case they cite not their own observations but Falconer's description of *Rhynchotherium*.

3. Freudenberg, 1922.—This confusion in the relationships of these various bunomastodonts unfortunately was not cleared up in Wilhelm Freudenberg's Memoir, "Die Säugetierfauna des Pliocäns und Postpliocäns von Mexiko, II. Teil: Mastodonten und Elefanten." Freudenberg himself was misled (pp. 113–115) by the very incomplete description by Leidy (1870 [1871]) of the type of *Mastodon shepardi*, also by Cope's designation of his Mexican specimen first as *Dibelodon shepardi* and second as the type of *Mastodon oligobunis*. He writes (Freudenberg, 1922, p. 115):

> Diese Entwicklungsgänge wurden in früherer Zeit ganz übersehen. Es war eine natürliche Folge hiervon, dass auf Grund ähnlicher Zahnformen schliesslich miocäne, pliocäne und diluviale Arten zusammengeworfen wurden. Die mexikanischen Arten trugen lange Zeit die Bezeichnung *M. Shepardi* [Footnote: '*Dibelodon Shepardi* Leidy aus Kalifornien und Mexiko (recte *M. oligobunis* Cope) wird wegen der mexikanischen *Mastodon*-Mandibeln aus den dortigen Quartärschichten zum Kronzeugen des Genus *Dibelodon* gemacht, neben *D. tropicus* Cope, tropisches Amerika, und *M. Humboldti* Cuv., Südamerika. (Obere Stosszähne mit Schmelzband, untere Stosszähne fehlen.) Copes Genus '*Mastodon*' (obere Incisiven ohne Schmelzband, untere fehlend) sei in Mexiko nicht vertreten, dagegen führt Cope einen *Tetrabelodon* aus Mexiko an, nämlich *Tetrabelodon Andium* Cuvier, Südamerika, Mexiko (obere Stosszähne mit Schmelzband—er denkt an *M. serridens*—, untere wenigstens bei den Männchen vorhanden)']. Cope hat seinen Irrtum später eingesehen und benannte den mexikanischen *Dibelodon* mit dem neuen Namen '*M. oligobunis*.'

Freudenberg was not justified by the supposed absence of the superior enamel band in removing Cope's type of *Mastodon oligobunis* from its relationship to *M. andium* (Freudenberg, quoting from Cope, 1922, p. 117):

> 'Nichts spricht dafür, dass die mexikanische Art ein Schmelzband an den oberen Molaren [Incisiven] besitzt. Ich beziehe darum die letztere Art auf das Genus *Mastodon* unter dem Artnamen *Mastodon oligobunis* Cope. Sie unterscheidet sich von *Dibelodon tropicus* in der kleineren Zahl von Jochen am letzten Molaren und in ihrer grösseren Einfachheit. Sie sind auch nicht längs geteilt, und nur die äusseren Hälften des ersten und zweiten Joches haben Sperrhügel (buttresses) vorn und hinten, wenigstens bei einigen Individuen.' Eine Abbildung gibt Cope nicht. Felix bildet unter dem Namen *M. Shepardi* einen letzten oberen Molaren aus Mexiko ab. (Palaeontographica. Vol. 37. 1891. t. 30.)

Through this error Freudenberg separated the four subspecies, which he proposed, from what appears to be their true phyletic affinity to *Cordillerion andium*. He concludes his review of these bunomastodonts (p. 118) as follows:

> Im folgenden unterscheide ich 4 verschiedene Mutationen oder Varietäten des *Mastodon* (*Dibelodon*) *oligobunis* Cope. Das sind: var. *antiquissima*, var. *Felicis*, var. *intermedia* und var. *progressa*. Vielleicht ist var. *antiquissima* identisch mit der verloren gegangenen Mandibel von Tlaxcala am Ostrande der Mesa central von Mexiko. Der Fundort Tlaxcala wird von Aguilera der Pliocänformation zugerechnet. Es sind blätterführende Tone mit Resten altertümlicher Säugetiere.

Referred to Cordillerion or possibly to Rhynchotherium.—In none of these types of Freudenberg do we observe the relatively broad proportions characteristic of M_3 in *Rhynchotherium tlascalæ*. The third superior molar figured by Felix as '*Mastodon shepardi*' (1891, Taf. xxx) and subsequently by Freudenberg (1922, Taf. x) as the type of '*Mastodon oligobunis felicis*' (see Fig. 516 of the present Memoir) appears to present the

proportions characteristic of *Cordillerion andium*, as displayed in figure 488 of the present Memoir, after Gervais. From the relatively narrow proportions of the type grinding teeth of these four subspecies, as reproduced in the present Memoir, we may provisionally refer them all to the genus *Cordillerion*, but comparison with the inferior grinding teeth of the types of *Rhynchotherium tlascala* and *R. falconeri* shows that we must be cautious in these references. Consequently:

Mastodon oligobunis Cope, 1893	= *Cordillerion oligobunis* of this Memoir
Mastodon oligobunis var. *antiquissima* Freudenberg, 1922	= *Cordillerion oligobunis antiquissimus* of this Memoir
Mastodon oligobunis var. *Felicis* Freudenberg, 1922	= *Cordillerion*(?) *oligobunis felicis* of this Memoir
Mastodon oligobunis var. *intermedia* Freudenberg, 1922	= *Cordillerion*(?) *oligobunis intermedius* of this Memoir
Mastodon oligobunis var. *progressa* Freudenberg, 1922	= *Cordillerion oligobunis progressus* of this Memoir

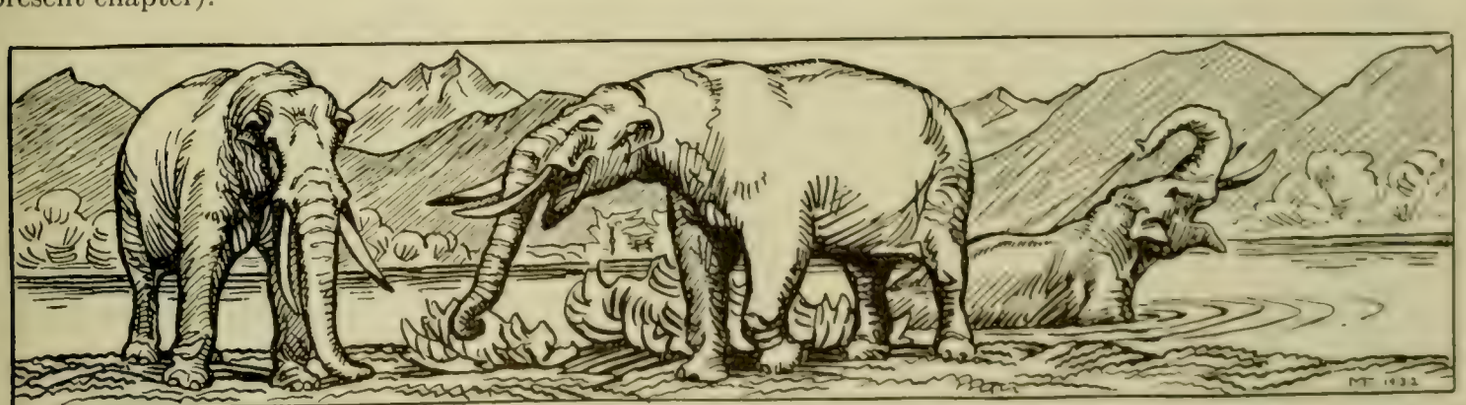
In his concluding review of these species, Freudenberg states that his four subspecies, *M. olig. antiquissima*, *M.olig. felicis*, *M. olig. intermedia* and *M. olig. progressa* constitute a series of *ascending* mutations which he terms varieties; the most progressive of these mutations, e.g., *M. oligobunis progressa*, is the most closely related to the type of *Dibelodon* [= *Cordillerion*] *tropicus* Cope.

6. TAMBLA TOOTH OF CENTRAL AMERICA

In 1859 Leidy mentioned the so-called "Tambla tooth" (Fig. 454) found near Tambla, Honduras, which later (1869, p. 242, Pl. XXVII, fig. 14) he described in detail and figured as possibly belonging to *Mastodon* [= *Cordillerion*] *andium*. It proves (Osborn, 1931) to be more primitive than *Rhynchotherium falconeri* (Fig. 468); it resembles *R. browni* of Sonora, Mexico (Fig. 467).

7. CALIFORNIA, TEXAS, AND ARIZONA SPECIES

(1) In 1921 Frick described the subspecies *Trilophodon* (*Tetrabelodon*) *shepardi edensis* from the Eden formation of southern California, now in part the type of *Cordillerion edensis*. (2) Five years later (1926) Hay published his paper on "A Collection of Pleistocene Vertebrates from Southwestern Texas," in which he described two new mastodonts from near Sinton, San Patricio County, namely, *Anancus orarius* and *A. defloccatus*. (3) In the same year Gidley named his *Anancus bensonensis*, found near Benson, Cochise County, Arizona. (4) Osborn has transferred these four species to the genus *Cordillerion* (see detailed description of these types below in the present chapter).



GROUP OF CORDILLERION EDENSIS FRICK, SAN BERNARDINO COUNTY, CALIFORNIA
RESTORED UNDER THE DIRECTION OF HENRY FAIRFIELD OSBORN BY MARGRET FLINSCH (1932)
One-fiftieth natural size

Fig. 500. The enamel-spiraled tusks and broad rostrum of this species enable us to restore this group, in the picturesque environment of Mt. Eden, as on its way to the Andes of South America. This is one of the most surprising and welcome results of the Upper Pliocene explorations of Joseph Rak, under the direction of Childs Frick.

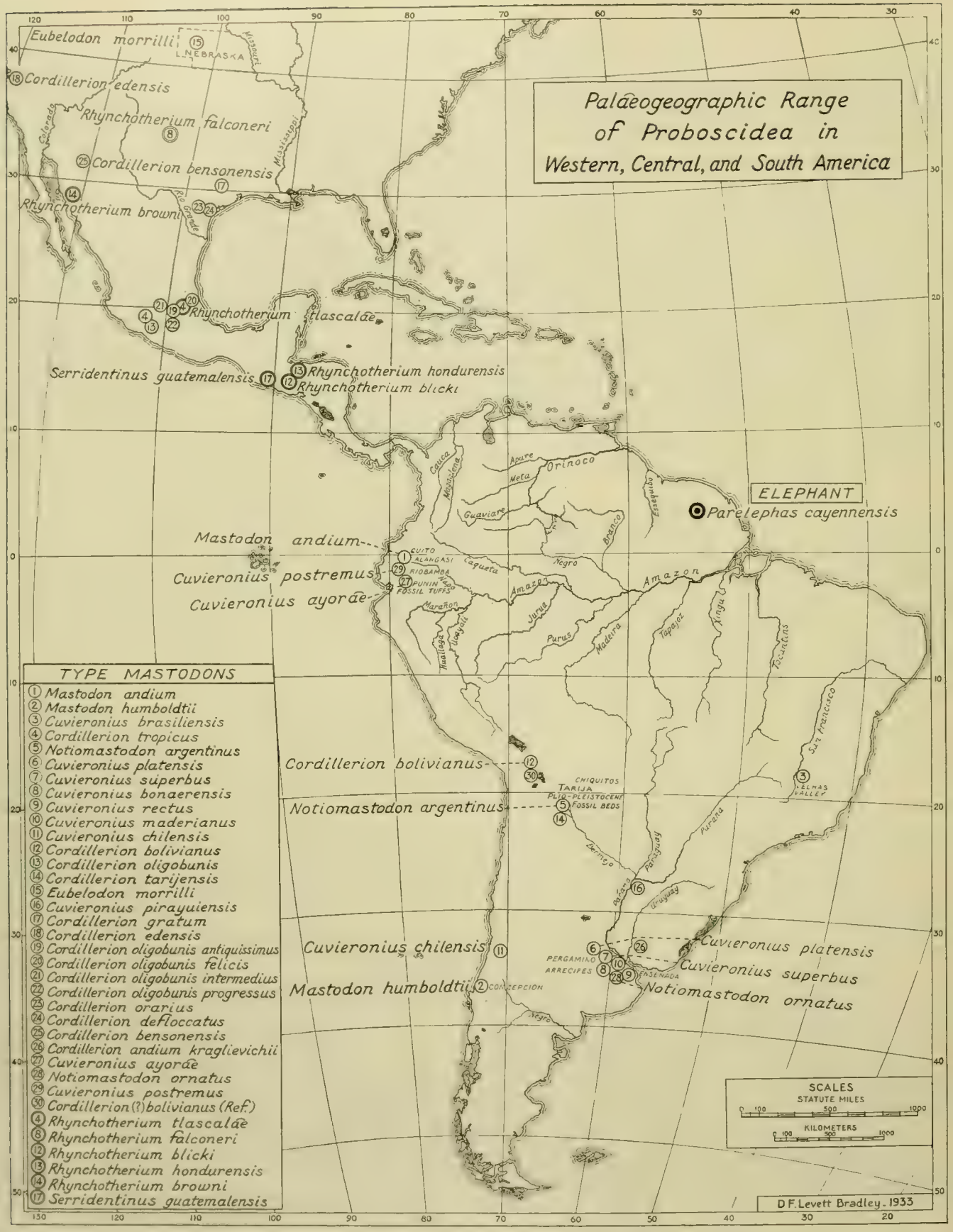


Fig. 501. Type localities of the thirty species of Mastodonts, ranging from the *Eubelodon morrilli* (15) of the 40th parallel north to the type '*Mastodon*' *humboldtii* (2) of the 40th parallel south, a total distance of 6,000 to 7,000 miles over the ancient migration routes from southern Nebraska to southern Argentina, expressing our palæogeographic knowledge up to the year 1933. Also the single species of elephant (*Parelephas cayennensis*) thus far discovered in South America. This map and the list opposite do not include the species of the *Stegomastodon mirificus* group recently (1934) added to the HUMBOLDTINÆ.

The species *Notiomastodon ornatus* (28) of the eastern, and *N. argentinus* (5) of the northwestern, Argentine are transferred in the present Memoir to the new family Serridentidæ, new subfamily Notiomastodontinæ (see Appendix to present Volume I), making twenty-eight species instead of thirty. The nearest known Serridentine of the north is the *Serridentinus guatemalensis* of Guatemala (17). (1935) The two species *Rhynchotherium blicki* (12) and *R. hondurensis* (13) should read *Blickotherium blicki* and *B. hondurensis*.

8. ORDER OF DISCOVERY AND DESCRIPTION OF THIRTY[1] SOUTH AND NORTH AMERICAN (MEXICO, TEXAS, CALIFORNIA, ARIZONA, NEBRASKA) SPECIES

This list and the map opposite do not include the species of the *Stegomastodon mirificus* group (Fig. 590) recently (1934) added to the Humboldtines.

See Figure 501

		Original Name	Previous Reference	Specific Reference in Present Memoir
	1602	Giant bones found in Tarija (*fide* Ameghino, 1889, p. 634; Boule, 1920, p. 1)		
1.	1806	*Mastodonte des Cordilières* Cuvier, Quito, Ecuador	= *Mastodon andium* Cuvier, 1824	= *Cordillerion andium*
2.	1806	*Mastodonte humboldien* Cuvier, Concepcion, Chile	= *Mastodon humboldtii* Cuvier in Desmarest, 1818; *M. humboldii* in Cuvier, 1824	= *Cuvieronius humboldtii*
1.	1814	*Mastotherium hyodon* Fischer de Waldheim, Cordilleras		= *Cordillerion andium*
2.	1814	*Mastotherium humboldtii* Fischer de Waldheim		= *Cuvieronius humboldtii*
2a.	1814	*Mastodon rhomboides* Rafinesque, Cordilleras		= *Cordillerion andium*
2b.	1814	*Mastodon humboldtianus* Rafinesque, South America		= *Cuvieronius humboldtii*
2.	1818	*Mastodon humboldtii* Cuvier in Desmarest, Concepcion, Chile		= *Cuvieronius humboldtii*
1.	1820–1822	*Mastodon cordillerarum* Desmarest, Quito, Ecuador		= *Cordillerion andium*
1.	1824	*M.* [*Mastodon*] *Andium* Cuvier, Quito, Ecuador		= *Cordillerion andium*
2.	1824	*M.* [*Mastodon*] *humboldii* Cuvier, Concepcion, Chile		= *Cuvieronius humboldtii*
3.	1842	*Mastodon Brasiliensis* Lund (in Lesson, 1842), Valley of the Velhas River, Province of Minas Geraes, Brazil		= *Cuvieronius* (?) *brasiliensis*
4.	1884	*Dibelodon tropicus* Cope, State of Michoacan, Valley of Mexico		= *Cordillerion tropicus*
5.	1888	*Mastodon argentinus* Ameghino, Argentina		= *Notiomastodon argentinus*[1]
6.	1888	*Mastodon platensis* Ameghino, lower Pampean formation, San Nicolás de los Arroyos, Province of Buenos Aires, Argentina		= *Cuvieronius platensis*
7.	1888	*Mastodon superbus* Ameghino, Pergamino, Province of Buenos Aires, Argentina		= *Cuvieronius superbus*
8.	1888	*Mastodon bonaerensis* Moreno, Arrecifes, Province of Buenos Aires, Argentina		= *Cuvieronius bonaerensis* (= *superbus*)
9.	1889	*Mastodon rectus* Ameghino, La Ensenada, near La Plata, Argentina		= *Cuvieronius rectus*
10.	1891	*Mastodon maderianus* Ameghino, Puerto Madero in Buenos Aires, Argentina		= *Cuvieronius* (?) *maderianus*
11.	1893	*Mastodon chilensis* Philippi, near Lake Tagua-Tagua, Chile		= *Cuvieronius chilensis*
12.	1893	*Mastodon bolivianus* Philippi, Ulloma, Bolivia		= *Cordillerion bolivianus*
13.	1893	*Mastodon oligobunis* Cope, Tequixquiac, Valley of Mexico		= *Cordillerion oligobunis*
14.	1902	*Mastodon tarijensis* Ameghino, Valley of Tarija, Bolivia		= *Cordillerion tarijensis*
15.	1914	*Eubelodon morrilli* Barbour, Devil's Gulch, south side of Niobrara River, Brown Co., Nebraska		= *Eubelodon morrilli*
16.	1915	*Mastodon pirayuiensis* Gez, Corrientes, Argentina		= *Cuvieronius pirayuiensis*
17.	1917	*Gomphotherium gratum* Hay, Pittbridge, Burleson County, Texas		= *Cordillerion gratum*
18.	1921	*Trilophodon* (*Tetrabelodon*) *shepardi edensis* Frick (in part), Mt. Eden Hot Springs, San Bernardino Co., California		= *Cordillerion edensis*
18.	1922	*Dibelodon edensis* Osborn (in part), Mt. Eden Hot Springs, San Bernardino Co., California		= *Cordillerion edensis*
19.	1922	*Mastodon oligobunis* var. *antiquissima* Freudenberg, Valley of Amajaque, Hidalgo, Mexico		= *Cordillerion oligobunis antiquissimus*
20.	1922	*Mastodon oligobunis* var. *Felveis* Freudenberg, Puebla, Mexico		= *Cordillerion*(?) *oligobunis felveis*
21.	1922	*Mastodon oligobunis* var. *intermedia* Freudenberg, Mexico		= *Cordillerion*(?) *oligobunis intermedius*
22.	1922	*Mastodon oligobunis* var. *progressa* Freudenberg, Cannada (canyon) de Aculcingo, Mexico		= *Cordillerion oligobunis progressus*
23.	1926	*Anancus orarius* Hay, near Sinton, Texas		= *Cordillerion orarius*
24.	1926	*Anancus defloccatus* Hay, near Sinton, Texas		= *Cordillerion defloccatus*
25.	1926	*Anancus bensonensis* Gidley, near Benson, Arizona		= *Cordillerion bensonensis*
26.	1928	*Mastodon andium Kraglievichii* Berro, Uruguay		= *Cordillerion andium kraglievichii*
27.	1928–1931	*Tetrabelodon* (*Bunolophodon*) *Ayorae* Spillmann, Quebrada von Chalang, near Punin, Province of Chimborazo, Ecuador		= *Cuvieronius ayora*
28.	1929	*Notiomastodon ornatus* Cabrera, Monte Hermoso, Province of Buenos Aires, Argentina		= *Notiomastodon ornatus*[1]
29.	1929–1931	*Bunolophodon postremus* Spillmann, Quebrada von Cachihuayco, near the village of Alangasi, Province of Pichincha, Ecuador		= *Cuvieronius postremus*
30.	1931	*Telcobunomastodon bolivianus* Revilliod, Valley of the Rio Desaguadero, Bolivia		= *Cordillerion* (?)*bolivianus* ref.

[1](1935) Twenty-eight, as the two species of *Notiomastodon* have been transferred to the Serridentidæ fam. nov., Notiomastodontinæ subfam. nov. (see Appendix to present Volume I). With the addition of the eight species of *Stegomastodon* (see p. 625 below), the Notorostrinæ and Humboldtinæ include thirty-six species in all.

II. SYNOPSIS AND PHYLOGENETIC REVISION UP TO 1929[1]

See Synopsis and Systematic Revision of 1934 (Sec. IV) at the close of this chapter. See also the Appendix to the present Volume I.

The previous historical introduction of the present Chapter XII sets forth clearly and fully the successive observations, opinions, and theories of Cuvier, Desmarest, de Blainville, D'Orbigny, Laurillard, Gervais, Lund, Ameghino, Moreno, Philippi, Nordenskiöld, Cope, Lull, Boule, Felix, Villada, and Freudenberg, and concludes with a list of the species described up to the close of the year 1931, so far as the literature accessible to the present author records. The recent reviews of Cabrera and Spillmann are treated in Sec. II, 6, 4 and 5.

The systematic revision for the present Memoir of the mastodonts of South America includes, first, the steps taken by Osborn to separate them as a new and distinct subfamily, the NOTOROSTRINÆ, and, second, to distinguish within this South American subfamily four distinct generic phyla, namely, *Cordillerion*, to include *Mastodon andium* and all the species related to it, *Cuvieronius*, to include *M. humboldtii* and all its related species, *Notiomastodon*, to include the genotype *N. ornatus* and provisionally the type of *'Mastodon' argentinus*, and the North American genus, *Eubelodon* Barbour, based on the species *Eubelodon morrilli* of Nebraska. A *provisional*[1] arrangement of these species, subject to further and closer examination of the type specimens of Ameghino, is as follows:

Cordillerion, including *M. andium* and related species:

Cordillerion andium Cuvier, 1806, 1824
" *tropicus* Cope, 1884
" *bolivianus* Philippi, 1893
" *oligobunis* Cope, 1893
" *tarijensis* Ameghino, 1902 (name only)
" *gratum* Hay, 1917
" (*Dibelodon*) *edensis* Osborn, 1922
" *oligobunis antiquissimus* Freudenberg, 1922
" *oligobunis felicis* Freudenberg, 1922
" *oligobunis intermedius* Freudenberg, 1922
" *oligobunis progressus* Freudenberg, 1922
" *orarius* Hay, 1926
" *defloccatus* Hay, 1926
" *bensonensis* Gidley, 1926
" *andium kraglievichii* Berro, 1928

Cuvieronius, including *M. humboldtii* and related species:

Cuvieronius humboldtii Cuvier, Desmarest, 1806, 1818, 1824
" *brasiliensis* Lund (in Lesson, 1842)
" *platensis* Ameghino, 1888
" *superbus* Ameghino, 1888
" *bonaerensis* Moreno, 1888
" *rectus* Ameghino, 1889
" *maderianus* Ameghino, 1891
" *chilensis* Philippi, 1893
" *pirayuiensis* Gez, 1915
" *ayoræ* Spillmann, 1928
" *postremus* Spillmann, 1929
Notiomastodon Cabrera, 1929
Notiomastodon ornatus Cabrera, 1929
" *argentinus* Ameghino, 1888
Eubelodon Barbour
Eubelodon morrilli Barbour, 1914

1. OSBORN'S SEPARATION OF THE SUBFAMILY NOTOROSTRINAE (1921–1926)

In 1918 Osborn (1918.468) began his publications on the phylogeny and systematic revision of the Proboscidea, stating his opinion (p. 133) "that Cope's method of morphological classification is untenable, that the only true and permanent classification is phylogenetic." By this method Osborn (table opp. p. 134) rightly revived the three genera of Falconer, *Trilophodon*, *Rhynchotherium*, and *Tetralophodon*, but Osborn fell into many errors, as indicated by subsequent corrections in [ ], in arranging the species within these three phyletic genera, e.g.:

Trilophodon (longirostral)	*Rhynchotherium* (medirostral)	*Tetralophodon* (brevirostral)
T. angustidens	*R. tlascalæ*	*T. humboldtii* [=*Cuvieronius*]
T. palæindicus	*R. euhypodon* [=*Blickotherium*]	*T. andium* [=*Cordillerion*]
T. campester [=*Tetralophodon*]	*?R. shepardi*=*Dibelodon* Cope [=*Rhynchotherium*]	*T. arvernensis* [=*Anancus*]
T. productus [=*Serridentinus*]	*R. brevidens*	*T. mirificus* [=*Stegomastodon*]
		T. hasnoti [=*Synconolophus*]

[1] This Section II has been further revised to embrace certain results of the researches by the present author up to the year 1935. For final classification, see Appendix to the present Volume I.

Beginning with this preliminary study of 1918 Osborn approached a truer conception of proboscidean phylogeny in 1921 (Osborn, 1921.515) in which the following arrangement appears:

LONGIROSTRINÆ Osborn

Trilophodon

T. angustidens Cuvier, genotype
T. productus Cope [= *Serridentinus productus*]
T. giganteus Osborn
T. obscurus Leidy
T. palæindicus Lydekker
T. floridanus Leidy [= *Ocalientinus* (*Ser.*) *floridanus*]
T. osborni Barbour, etc.

Tetralophodon

T. longirostris Kaup, genotype
T. campester Cope
T. punjabiensis Lydekker
T. corrugatus Pilgrim [= *Synconolophus corrugatus*]

BREVIROSTRINÆ Osborn

Mastodon

M. andium Cuvier, genotype [= *Cordillerion andium*]
M. humboldtii Desm., Cuvier [= *Cuvieronius humboldtii*]
M. (*Dibelodon*) *tropicus* Cope [= *Cordillerion tropicus*]
M. successor Cope [= *Stegomastodon successor*]
?Eubelodon morrilli Barbour [= *Eubelodon*]

Cope had previously suggested (1884) that his *Dibelodon tropicus* was close to *Mastodon andium*. Osborn observed (1921.515, p.10) that *Eubelodon morrilli* (Barbour, 1914.1) exhibits an abbreviated lower jaw, no lower tusks, superior tusks without enamel band, thus differing from *M.* [= *C.*] *andium* in one important character only, namely, in the absence of an enamel band, while agreeing in the absence of the lower tusks. This was the third genuine approach to a true phylum, because both Lull and Cope had previously observed the affinities of the Texas, Mexican, and South American species.

In the same year Osborn (1921.526, p. 330) clearly distinguished as a new subfamily the short-jawed Notorostrines of South America from the short-jawed Brevirostrines of Eurasia and North America by the fundamental difference in the structure of their grinding teeth, and fully characterized the Notorostrinæ as follows:

> The *Notorostrinæ* include all the Central and South American brevirostrines, which are also abundant in the southwestern United States—for example, Texas (Blanco formation), Mexico, the Andean, and the Pampean regions. They were distinguished in my second paper as 'The brevirostrines of South America,' embracing the classic species *M. andium* Cuv., *M. humboldtii* Cuv.; also *M. tropicus* Cope (Valley of Mexico), *M. successor* Cope (Blanco of Texas). They possibly sprang from or are related to *Eubelodon morrilli* Barbour, 1913 [1914], from the Lower Pliocene, Nebraska. The fact that these animals are not only profoundly separated from the *other* bunomastodonts by the progressive abbreviation of the jaw, but that they are the only members of the great order Proboscidea which, so far as known at the present time, entered the South American continent, will probably convince reluctant paleontologists that they constitute a distinct subfamily, which may be named the Notorostrinæ [Footnote: 'From the Latin of Virgil, 'notus,' a southwest wind;' . . .] or short-jawed mastodons of the South American continent. There is a very great variety of form among the ten species which have been described, including, in addition to those mentioned above, *M. bolivianus* Philippi, *M. chilensis* Philippi, *M. platensis* Ameg., *M. rectus* Ameg., *M. argentinus* Ameg., and *M. superbus* Ameg. The two beautiful skulls in the Stockholm Museum, referred to *M. andium* by Nordenskjold, display a spiral twist of the tusks—a feature quite unique among Proboscideans.

This subfamily distinction was more fully stated in a paper on the "Migrations and Affinities of the Fossil Proboscideans of Eurasia, North and South America, and Africa" (compare Osborn, 1922.566, p. 454):

NOTOROSTRINÆ OSBORN, 1921

Notorostrinæ, a special branch entering the Andean region of South America and spreading over the South American continent, distinguished by the loss of the lower tusks and the abbreviation of the jaw.

Mastodon andium Cuv.
Mastodon humboldtii Desm., Cuv.,
Dibelodon tropicus Cope
} All included within the genus *Dibelodon* Cope

Eubelodon morrilli Barbour

RHYNCHOROSTRINÆ OSBORN, 1918, 1921

Rhynchorostrinæ, beaked bunomastodonts, known [chiefly] in the southern United States and northern Mexico, with powerful downturned upper and lower tusks.

Mastodon shepardi Leidy
Mastodon cuhypodon Cope
Tetrabelodon brevidens Cope
} All included within the genus *Rhynchotherium* Falconer

Rhynchotherium tlascalæ Osborn

BREVIROSTRINÆ OSBORN, 1918, 1921

Brevirostrinæ, short-jawed bunomastodonts, which imitate both the true mastodonts and the elephants in the abbreviation of the lower jaw and the early loss of the inferior tusks.

Mastodon arvernensis Croiz. et Job.
Mastodon sivalensis Cautley
Mastodon mirificus Leidy [in 1934 transferred to the Humboldtines].
} All included within the genera *Anancus* Aymard, *Pentalophodon* Falconer, and *Stegomastodon* Pohlig

2. OSBORN (1923–1926) SEPARATES THE GENERA CORDILLERION AND CUVIERONIUS

In 1923 (Osborn, 1923.601) the fourth step was taken in separating *Mastodon humboldtii* Cuvier as the genotypic species of a new genus *Cuvieronius* from the genus *Dibelodon* Cope which seemed to Osborn at the time to be the only generic name properly applicable to *Mastodon andium*. This citation is as follows:

> Among the new genera and species of Proboscidea are the following. *Cuvieronius*, new genus. Based upon the genotypic species *Mastodon humboldtii* Cuv. This genus is distinguished by double trefoils in the superior and inferior grinding teeth, also by simple, rounded, outwardly and upwardly curved tusks lacking the enamel bands. The distinctions long observed as separating the species *Mastodon humboldtii* from *M. andium* also serve to distinguish the genus named in honor of Cuvier from the genus *Dibelodon* Cope which seems to be the only generic name properly applicable to *M. andium*.

The fifth step (Osborn, 1926.706, p. 15), taken in preparation for the present Memoir, was the proposal of the new generic name *Cordillerion*, based on the genotypic species *Mastodon Andium* Cuvier, 1824. The genus *Dibelodon* Cope, neither by definition nor by its genotypic species *Mastodon shepardi* Leidy, can be applicable to *Mastodon andium*. As shown above in Chapter XI, *Mastodon shepardi* Leidy belongs among the Rhynchorostrinæ and should be described as *Rhynchotherium shepardi* Leidy, so far as we can judge from the superior incisive tusks which constitute the type of this species.

The sixth step (1927), taken in this Memoir, is to clearly distinguish the genus *Cordillerion* Osborn from the genus *Cuvieronius* Osborn, taking advantage of the previous observations of the authors cited above and of the more or less detailed descriptions below of the chief characters of the two genotypic species, and to add provisionally Barbour's genus *Eubelodon*.

Notorostrinæ	Humboldtinæ[1]	
Cordillerion Osborn, 1926. Genotypic species: *Mastodon andium* Cuvier, 1806, 1824.	*Cuvieronius* Osborn, 1923. Genotypic species: *Mastodon humboldtii* Cuvier, 1806 (in Desmarest, 1818).	*Eubelodon* Barbour, 1914. Genotypic species: *Eubelodon morrilli* Barbour, 1914.
1. Broad enamel band on superior tusks.	1. No enamel band on superior tusks.	1. No enamel band on downturned superior tusks.
2. Single trefoils on the superior and inferior grinding teeth. Cement in progressive stages.	2. Double trefoils on the superior and inferior grinding teeth.	2. Double trefoils on the superior and inferior grinding teeth; four ridge-crests only.
3. Rostrum of lower jaw of medium length, without lower incisive tusks.	3. Rostrum of lower jaw abbreviated as in *Mastodon*, without lower incisive tusks.	3. Rostrum of lower jaw relatively elongated, without lower incisive tusks.
4. Cranium depressed with elongated preorbital facial region or maxillary rostrum correlated with elongated mandibular rostrum.	4. Cranium relatively tall, abbreviated or brachycephalic, preorbital facial or maxillary rostrum abbreviated, corresponding with the abbreviated mandibular rostrum.	4. Cranium ancestral. Preorbital region probably elongated, corresponding with the elongated mandibular rostrum.
5. Third superior and inferior molars relatively narrow, with 4½ to 4¾ ridge-crests, apparently 5½ ridge-crests on l.M_3 of referred *Cordillerion bolivianus* (Fig. 512), also on r.M_3 of *C. tropicus* (Fig. 513).	5. Third superior and inferior molars somewhat broader, ridge-crests 5¼ to 5⅓.	8. As shown below (Sec. III, pp. 602–606), Barbour's aged type specimen (Figs. 567, 569–571) is quite distinct from *Trilophodon*, *Tetralophodon*, *Serridentinus*, *Rhynchotherium*, and *Cordillerion*. Its affinity to *Cuvieronius* and the Notorostrines remains to be determined by further research.
6. Second superior and inferior molars four crested or tetralophodont[2] in Tarija form (see Fig. 504, 5, after Gervais); other intermediate molars three crested (see Fig. 504, 6, also Fig. 486).	6. All intermediate molars said to be three crested or trilophodont.[3]	
7. Enamel usually less folded (*fide* Boule).	7. Enamel usually more folded, as observed in worn teeth (*fide* Boule).	
8. Symphysis longer and less downturned (*fide* Boule).	8. Symphysis of lower jaw shorter (*fide* Boule).	
9. Found chiefly on the high plateaus of the Cordilleras.	9. Found chiefly in the pampas of Buenos Aires and in Brazil.	

Note, 1933: Since the above was written, the nearly complete type skeleton of *Eubelodon morrilli* has been mounted in the Nebraska Museum (Fig. 573), also a fine cranium (Fig. 574) has been discovered and briefly described by Frick (1933, p. 598). Thus our knowledge of *Eubelodon* in comparison with *Cuvieronius* is now greatly extended.

[1] Subfamily name assigned in 1934 (see p. 575 below).

[2] Boule observes under *Mastodon andium* (1920, p. 63): "4. Trilophodonte, mais avec un talon assez développé pour présenter parfois une tendance vers la forme tétralophodonte."

[3] Boule observes under *Mastodon humboldtii* (1920, p. 63): "4. Trilophodonte."

It now seems certain that *Eubelodon morrilli* belongs to Group III, and can no longer be regarded as an offshoot of the *Tetralophodon* phylum as at first appeared, the characters of the superior tusks and of the type lower jaw (Figs. 567, 569, 570) on the whole tending to place *Eubelodon* among the Humboldtinæ.

It is premature to attempt a phylogenetic rearrangement of the Mexican and North and South American species within the four South American genera; but it is certain that these species do include four to five genera. Ameghino defined his species chiefly by the characters of the superior incisive tusks, leaving uncertain the characters of the grinding teeth in these species; Boule (1920) groups the species quite differently from the grouping by Osborn (1933) below. Osborn's grouping is based principally upon the characters of the superior tusks, but also upon the abbreviation or elongation of the lower jaw, and upon the presence of single or double trefoils, as indicated in the definition above. See also figure 498, and synopsis at the close of this chapter (Sec. IV).

THE FOUR TO FIVE (1933) NOTOROSTRINE GENERIC PHYLA

GROUP I

Cordillerion = *Mastodon andium* group, with enamel band on tusks and elongated rostrum; *single* trefoils, molars narrow.

Cordillerion andium Cuvier, Cordilleras, near Quito, Ecuador.

Cordillerion tropicus Cope, State of Michoacan, Valley of Mexico.

Cordillerion tarijensis Ameghino, Valley of Tarija, Bolivia.

Cordillerion bolivianus Philippi, Ulloma, Bolivia.

Cordillerion oligobunis Cope, Tequixquiac, Mexico.

Cordillerion gratum Hay, Pittbridge, Burleson County, Texas.

Cordillerion edensis Osborn, Mt. Eden Hot Springs, southern California.

Cordillerion oligobunis antiquissimus Freudenberg, Valley of Amajaque, Hidalgo, Mexico.

Cordillerion(?) *oligobunis felicis* Freudenberg, Puebla, Mexico.

Cordillerion(?) *oligobunis intermedius* Freudenberg, Mexico.

Cordillerion oligobunis progressus Freudenberg, Cannada de Aculcingo, Mexico.

Cordillerion orarius Hay, near Sinton, Texas.

Cordillerion defloccatus Hay, near Sinton, Texas.

Cordillerion bensonensis Gidley, near Benson, Arizona.

Cordillerion andium kraglievichii Berro, Uruguay.

GROUP II

Cuvieronius = *Mastodon humboldtii* group, no enamel band on tusks, rostrum abbreviated, *double* trefoils, molars broad.

Cuvieronius humboldtii Cuvier (in Desmarest), Concepcion, Chile.

Cuvieronius brasiliensis Lund (in Lesson), Brazil.

Cuvieronius platensis[1] Ameghino, Pampas, Province of Buenos Aires, Argentina.

Cuvieronius superbus Ameghino, Province of Buenos Aires, Argentina.

Cuvieronius bonaerensis Moreno, Arrecifes, Argentina.

Cuvieronius rectus[1] Ameghino, La Ensenada near La Plata, Province of Buenos Aires, Argentina.

Cuvieronius maderianus Ameghino, Province of Buenos Aires, Argentina.

Cuvieronius chilensis Philippi, near Lake Tagua-Tagua, Chile.

Cuvieronius pirayuiensis Gez, Argentina.

Cuvieronius ayoræ Spillmann, near Punin, Ecuador.

Cuvieronius postremus Spillmann, near Alangasi, Ecuador.

GROUP III

Eubelodon = *Eubelodon morrilli* group, no enamel band, rostrum elongated, *double* trefoils, molars broad. No inferior tusks.

Eubelodon morrilli Barbour, Devil's Gulch, Brown County, Nebraska.

Eubelodon resembles *Cuvieronius* in the presence of only four complete crests on M_3 and of double trefoils, also in the absence of an enamel band.

[1]According to the tabular arrangement of Ameghino (1889) and of Boule (1920), this species has *single* trefoils, not double.

GROUP V

Stegomastodon: Species ranging from Nebraska to Texas, described in Chapter XIII as Brevirostrines, prove (1933) to be nearer the Humboldtines.

GROUP IV

Notiomastodon Cabrera, 1929, including the genotypic species *Notiomastodon ornatus* Cabrera, from the inferior Pampean, Monte Hermoso, Province of Buenos Aires, Argentina. Superior tusks upturned [or downturned] with broad lateral enamel band, rostrum of medium length, molars narrow with double trefoils.

Notiomastodon argentinus Ameghino, Valley of Tarija, Argentina.

NOTE: The two species of this group, namely, the type species *Notiomastodon ornatus* Cabrera, 1929, and *M.* [= *Notiomastodon*] *argentinus* Ameghino, 1888, are represented by both authors as having upturned tusks exhibiting a broad external enamel band. While no associated portions of the maxillæ have thus far been reported, this seems to be a mechanically impossible position, because all the known mastodont superior tusks with enamel band, e.g., *Trilophodon*, *Serridentinus*, *Rhynchotherium*, *Tetralophodon*, etc., exhibit *downturned* enamel-banded tusks. Accordingly the restorations in the present Memoir exhibit downturned tusks.

The generic and subfamily affinities of *Notiomastodon* are still a matter of conjecture. Since members of the Rhynchorostrinæ, e.g., *Rhynchotherium tlascalæ*, penetrated middle America as far south as the plateau of Mexico, it would appear possible that they migrated farther southward and that *Notiomastodon* may thus prove to be related to the Rhynchorostrinæ. Finally, in the Appendix to the present Volume I, made the type of the Notiomastodontinæ, of the Serridentidæ fam. nov.

SUPERFAMILY: MASTODONTOIDEA Osborn, 1921
FAMILY: BUNOMASTODONTIDÆ Osborn, 1921 (syn. GOMPHOTHERIIDÆ Cabrera, 1929)

SUBFAMILY: NOTOROSTRINAE[1] Osborn, 1921

Original reference: Bull. Geol. Soc. Amer., 1921, Vol. XXXII, pp. 330, 331 (Osborn, 1921.526).
Synonyms in part: Cuvieroniinae Cabrera, 1929, p. 76, based on '*M.*' *andium* group; Anancinae Cabrera, 1929, p. 76, based on '*M.*' *humboldtii* group.

SUBFAMILY CHARACTERS.—(1) Cranium elephantoid, more elevated (*Cuvieronius*); mastodontoid, more depressed (*Cordillerion*). (2) Rostrum of jaw abbreviated and somewhat downturned (*Cuvieronius*); less abbreviated and more horizontal (*Cordillerion*). (3) Jaws broad, deep, and abbreviated (brevirostral). (4) Superior incisive tusks straight or upturned, without enamel band (*Cuvieronius*); spiral or horizontal, with broad enamel band (*Cordillerion*). (5) Inferior incisive tusks entirely wanting in adult stages, probably present in juvenile stages. (6) Grinding teeth persistently brachyodont with single trefoils (*Cordillerion*), with double trefoils (*Cuvieronius*). In respect to trefoil structure, *Cordillerion* is parallel with *Trilophodon*, e.g., trefoils single above and below in M 3, with 4 to 4½ to 5½ ridge-crests; *Cuvieronius* is parallel with *Tetralophodon*, e.g., trefoils double above and below in M 3, with 5 to 5½ ridge-crests. (7) Intermediate grinders with a tendency to tetralophodonty in M^2-M_2 (*Cordillerion*); otherwise trilophodont in M^1-M_1, M^2-M_2 (*Cordillerion* and *Cuvieronius*). In final phyletic stages the grinding-tooth action concentrated on second and third superior and inferior molars (Figs. 495, 497). (8) Superior incisive tusks actively functional, as in the Brevirostrinæ; inferior incisive tusks wanting or functionless, in contrast to the Rhynchorostrinæ and the phylum *Trilophodon* of the Longirostrinæ. (9) Undoubtedly of Old World ancestry, but, with the exception of the doubtful Nebraska *Eubelodon morrilli*, thus far known only in California, Texas, Arizona, Mexico, and South America.

Osborn, 1933: This subfamily of short-jawed bunomastodonts is monophyletic, as seen in the clear separation of the numerous characters of the *Cordillerion andium* phylum from the *Cuvieronius humboldtii* phylum. Only five bunomastodonts which can be regarded as related to *Cordillerion andium* have thus far been discovered in North America, namely, the *Cordillerion gratum*, *C. orarius*, and *C. defloccatus* Hay, all of Texas, the *C. bensonensis* Gidley of Arizona, and the *C. edensis* Osborn of California, and five new species and subspecies from Mexico described by Cope and Freudenberg. There are considerable grounds for the supposition that the *Eubelodon morrilli* of Barbour, discovered in Nebraska in 1913, may be ancestral to *Cuvieronius humboldtii*.

Osborn, 1934: The Notorostrinae are now subdivided into three subfamilies namely, (1) Subfam. NOTOROSTRINÆ (restricted to *Cordillerion andium* group), (2) Subfam. NOTIOMASTODONTINÆ[1] (*Notiomastodon ornatus*), (3) Subfam. HUMBOLDTINÆ (restricted to *Cuvieronius humboldtii* group, including *Eubelodon morrilli* and *Stegomastodon*), fully defined in the Appendix at the close of the present Volume I.

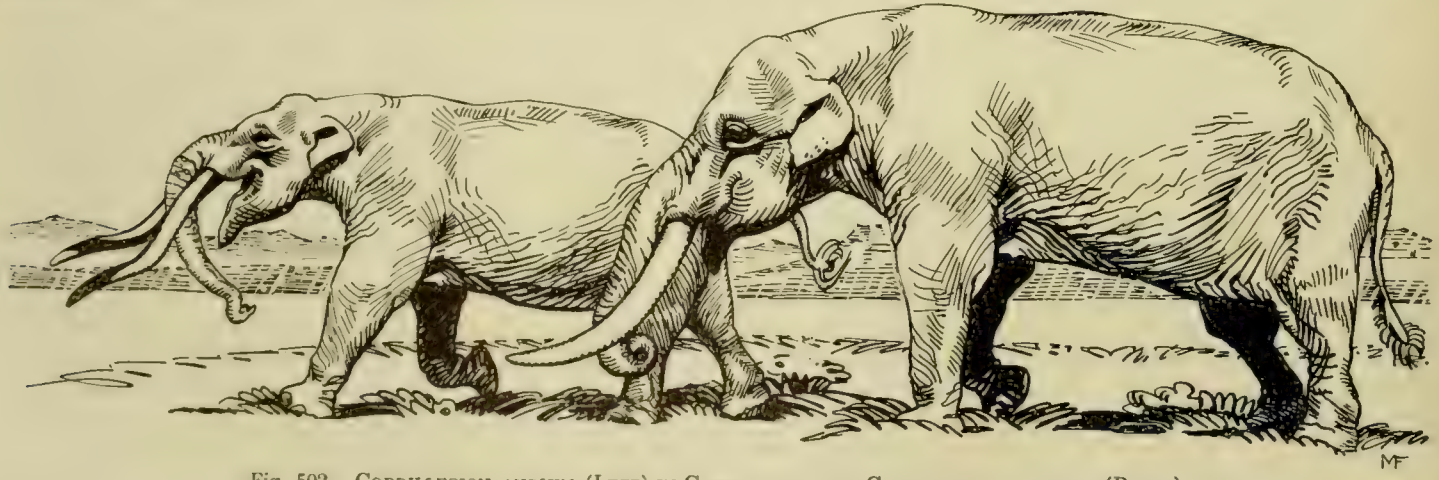


Fig. 502. CORDILLERION ANDIUM (LEFT) IN COMPARISON WITH CUVIERONIUS SUPERBUS (RIGHT)
RESTORED UNDER THE DIRECTION OF HENRY FAIRFIELD OSBORN BY MARGRET FLINSCH (1933), ONE-FIFTIETH NATURAL SIZE

[1]See introductory note on page 515 of the present chapter.

3. SYSTEMATIC REVISION OF THE GENUS CORDILLERION AND ITS INCLUDED SPECIES UP TO THE YEAR 1927

FAMILY: BUNOMASTODONTIDÆ Osborn, 1921
SUBFAMILY: NOTOROSTRINÆ Osborn, 1921

GENUS: **CORDILLERION** Osborn, 1926

Original reference: Amer. Mus. Novitates, No. 238, p. 15 (Osborn, 1926.706).
Genotypic species: *Mastodonte des Cordilières* Cuvier, 1806 = *Mastodon andium* Cuvier, 1824.
Synonym in part = *Dibelodon* Cope, 1884; *Telebunomastodon* Revilliod, 1931, genotypic species *Mastodon bolivianus* Philippi, 1893. Compare *Mastotherium hyodon* Fischer de Waldheim, 1814.

GENERIC CHARACTERS.—(1) Superior tusks with a broad enamel band which is wound more or less spirally around the elongated tusk; (2) no inferior tusks; (3) grinding teeth narrow with sharply defined *single* trefoils on the internal side of the superior molars and on the external side of the inferior molars as in other bunomastodonts with single trefoils; (4) third superior and inferior grinding teeth moderately elongate, ridge-crest formula, M 3 $\frac{4\text{-}5}{4\text{-}4\frac{1}{2}\text{-}5\frac{1}{2}}$; (5) intermediate molars typically three crested (trilophodont), or four crested (subtetralophodont); (6) superior and inferior molars invariably brachyodont, never hypsodont; (7) cranium depressed, as in *Trilophodon;* (8) adaptation chiefly to a mountain habitat, grinders adapted principally to a browsing habit, tusks used in the uprooting of plants for food; (9) frequent in high Cordilleran region, rare in Pampean region of Argentina; (10) central conules more or less conspicuous.

This generic name replaces the preoccupied name *Dibelodon* as used by Cope and Lull to embrace the two species *Mastodon andium* and *M. humboldtii*. *Cordillerion* refers only to species possessing the above characters in common.

These generic characters are more or less clearly displayed in the type specimens of the following thirteen species:

SOUTH AMERICA	MEXICO	TEXAS, CALIFORNIA, AND ARIZONA
Cordillerion andium Cuvier, 1824	*Cordillerion tropicus* Cope, 1884	*Cordillerion gratum* Hay, 1917
" *bolivianus* Philippi, 1893	" *oligobunis* Cope, 1893	" (*Dibelodon*) *edensis* Osborn, 1922
	" " *antiquissimus* Freudenberg, 1922	" *orarius* Hay, 1926
	" " *felicis* Freudenberg, 1922	" *defloccatus* Hay, 1926
	" " *intermedius* Freudenberg, 1922	" *bensonensis* Gidley, 1926
	" " *progressus* Freudenberg, 1922	

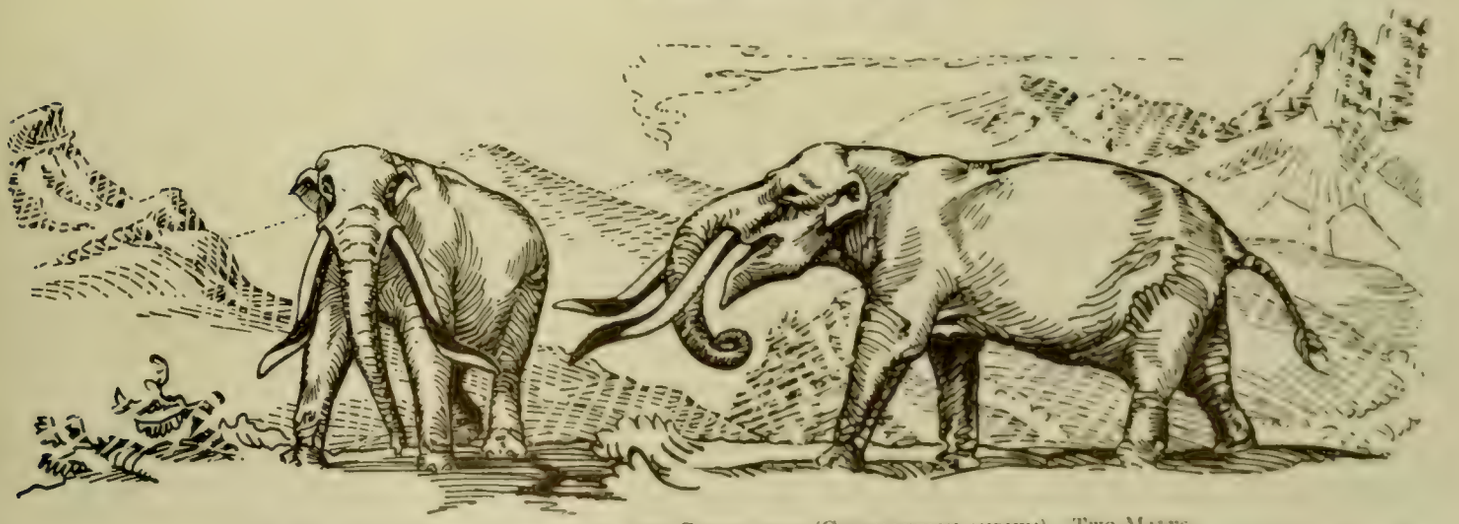
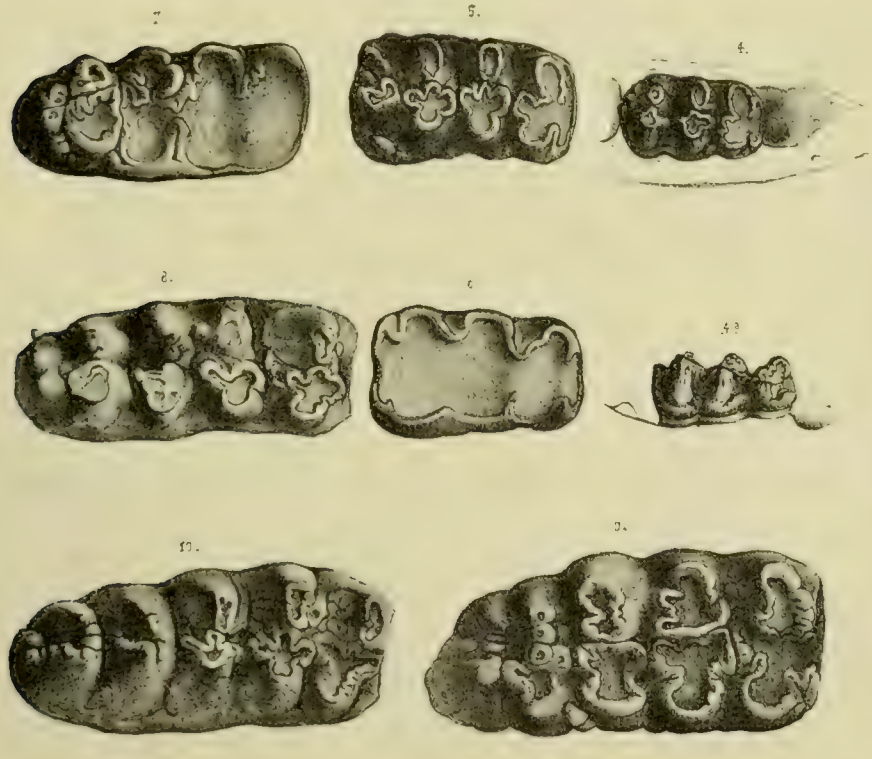


Fig. 503. THE ANDEAN MASTODONT OF THE CORDILLERAS (CORDILLERION ANDIUM) TWO MALES
RESTORED UNDER THE DIRECTION OF HENRY FAIRFIELD OSBORN BY MARGRET FLINSCH (1933), ONE-FIFTIETH NATURAL SIZE. (COMPARE FIG. 484.)

Burmeister, 1889.—Burmeister in his Memoir of 1889 describes and compares at great length (pp. 32–50) the remarkable collection in the Museo Nacional, which at the time included three more or less well-preserved lower jaws of *M.* [=*Cuvieronius*] *humboldtii* and seven individuals of *M.* [=*Cordillerion*] *andium* in different stages of development. As to the locality of these specimens, Burmeister (*op. cit.*, p. 33) observes:

> Wir besitzen im hiesigen Museo Nacional zahlreiche Reste von beiden Arten, welche auch in der Provinz von Buenos Aires neben einander lebten und mittelst dieser Fundstücke ihre Verschiedenheit entscheidend darthun. Es genügt, die vollständigen Unterkiefer beider in unserer Sammlung neben einander zu stellen, um Jedermann von ihrer specifischen Differenz zu überzeugen. Von *M. Humboldtii* liegen mir ausserdem noch drei mehr oder weniger guterhaltene Unterkiefer vor; von *M. Antium* [Footnote: 'Ich ziehe diese Form vor, weil mir *Antium* dem Genius der lateinischen Sprache angemessener erscheint.'] sogar sieben in sehr verschiedenen Altersstufen, vom eben geborenen bis zum ausgewachsenen Thiere.



Cordillerion (upper rows) and Cuvieronius (lower row) Grinding Teeth

After Gervais. All reduced to the same one-fourth scale

Fig. 504. Grinding teeth of *Cordillerion* (4–8) and of *Cuvieronius* (9, 10), after Gervais, 1855. One-fourth natural size. Originals probably in the Muséum d'Histoire Naturelle, Paris.

Two upper rows: Referred inferior grinding teeth of *Mastodon* [=*Cordillerion*] *andium*, with single trefoils. From Tarija, Bolivia. After Gervais, 1855, Pl. v, figs. 4–8 inc. Nos. 4, 4*a*, 5, 6, and 8 are inferior molars of *Cordillerion andium*. No. 7 is a superior (?) molar with double trefoils.

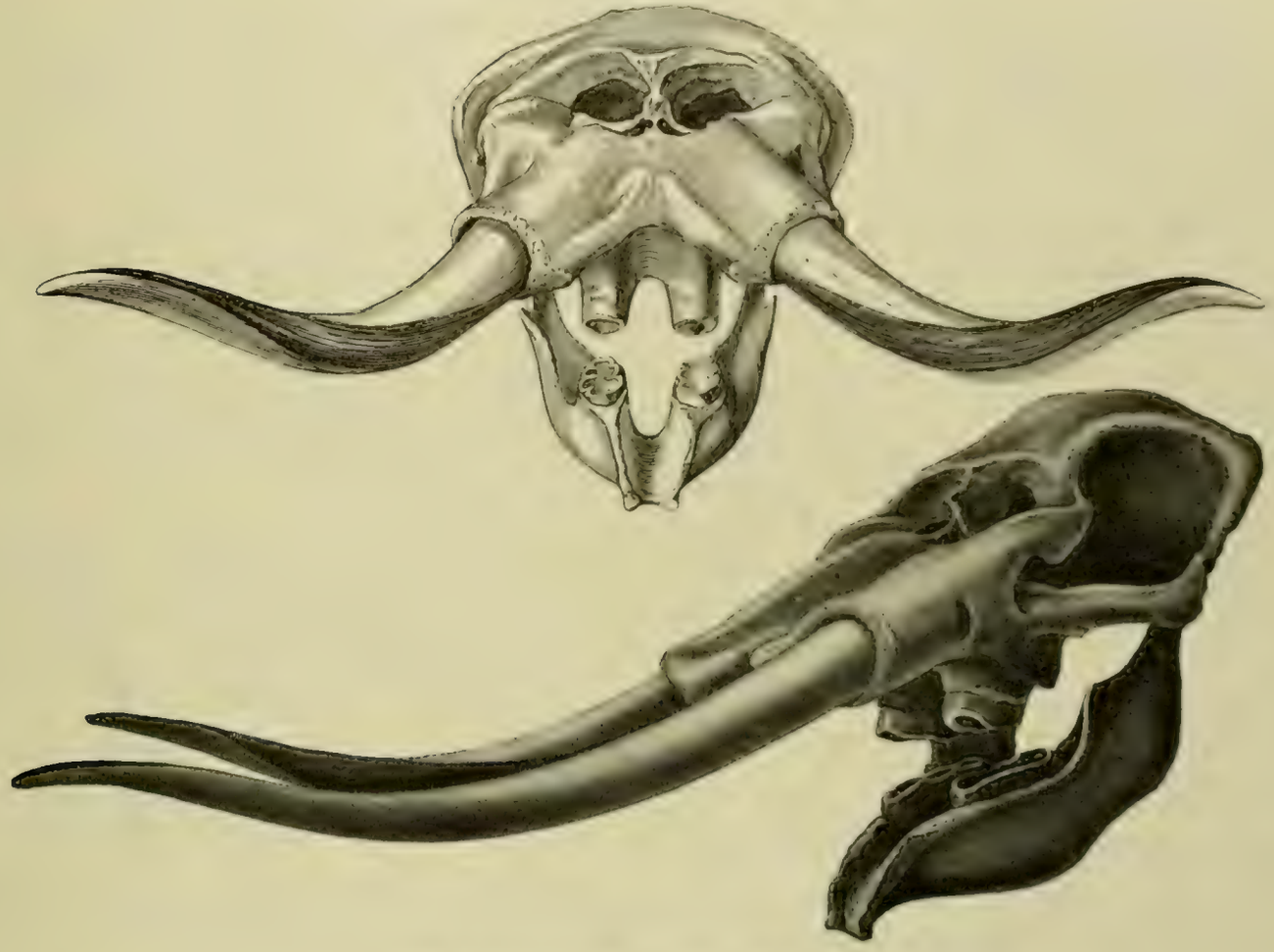
Lower row: Referred superior (9) and inferior (10) grinding teeth of *Mastodon* [=*Cuvieronius*] *humboldtii*, with double trefoils. From Buenos Aires and Santa Fé de Bogota. After Gervais, 1855, Pl. v, figs. 9 and 10. No. 9 is a right third superior molar, r.M^3, of *Cuvieronius* (?)*platensis* with 5+ ridge-crests; No. 10 is a third right inferior molar, r.M_3,of the same species with 5+ ridge-crests.

Lower row: Figures 9 and 10, referred by Gervais to *Cuvieronius humboldtii*, exhibit 5⅓ ridge-crests, corresponding accordingly with the third inferior (10) and third superior (9) grinders referred to *C. platensis* Amegh. (Cf. Fig. 560 of the present Memoir.)

Third Molar Proportions in Rhynchotherium, Cordillerion, Cuvieronius, and Eubelodon

Both *Cordillerion* and *Rhynchotherium* occur in Mexico, and *Serridentinus* has been found as far south as Guatemala. The attention of the reader is directed above in this Memoir (p. 483) to the table showing the comparative proportions of *Rhynchotherium* and *Serridentinus* grinders, in which it is demonstrated that the third inferior grinding teeth, M_3, are substantially equal in relative breadth and length, the maximum breadth-length index of M_3 being 55 and 47 respectively; also to the proportions of the *Rhynchotherium* and *Cordillerion* grinders, on page 533 of the present chapter.

In the accompanying table (p. 545) it is shown that the inferior grinders of *Cordillerion* are relatively narrower than those of *Rhynchotherium;* in fact, we may usually distinguish the third superior and inferior grinders of *Cordillerion* by their relatively narrow and uniformly oblong shape; the same is true of some species of *Cuvieronius*, as clearly shown in figure 504; as a rule the *Cuvieronius* grinders are larger than those of *Cordillerion*



CRANIUM OF CORDILLERION ANDIUM, AFTER BURMEISTER

Fig. 505. Cranium of *Cordillerion andium*, after Burmeister (*Mastodon antium*), 1889: Pl. IX, fig. 1, anterior view; Pl. X, fig. 1, left lateral view, direct from lithographic figure. About one-tenth natural size.

COMPARATIVE BREADTH-LENGTH INDICES OF THIRD INFERIOR MOLAR, M_3

	ap.	tr.	I.
Rhynchotherium browni, type, broad grinders,	176–180	96	53–55
Rhynchotherium falconeri type, broad grinders,	168–173	80	46–48
Rhynchotherium [=*Blickotherium*] *euhypodon* type, narrow grinders,	182	78	43
Cordillerion tropicus Cope, after von Meyer, 1867, narrow grinders,	188	82	44
Cordillerion andium Cuvier, after Gervais, 1855, narrow grinders,	195e	78	40
Cuvieronius humboldtii Cuvier [=*C.* (?)*platensis*], after Gervais, 1855, broader grinders,	225e	105	47e
Eubelodon morrilli Barbour, 1914, broader grinders,	202	90	45

From the above comparative measurements of the third inferior grinding teeth in *Rhynchotherium*, *Cordillerion*, and *Cuvieronius*, it appears that the *type* inferior grinders of *R.* [*Blickotherium*] *euhypodon* also are relatively narrow and long, the breadth-length index being 43, the same index as prevails in the species of *Cordillerion*.

TUSKS.—That the similarity in grinding tooth structure of the Longirostrines and Notorostrines is a case of *parallelism* rather than of congeneric affinity is shown by the contrast in the tusks or incisive teeth:

Trilophodon and *Tetralophodon* superior incisors: Sharply downturned, with enamel band.
Trilophodon and *Tetralophodon* inferior incisors: Horizontal, elongated, well developed, without enamel band.
Cuvieronius and *Cordillerion* superior incisors: Upturned, without enamel band (*Cuvieronius*); downcurved and spiral, with broad enamel band (*Cordillerion*). No inferior tusks.

Adaptations of Tusks and Skull

The structure of the tusks and skull is superbly shown in a specimen in the National Museum of Buenos Aires, as figured by Burmeister (1889) and reproduced in our figure 505.

Cranial Structure.—The admirable comparative figures of the cranium of *Elephas*, of *Mastodon* [=*Cuvieronius*] *humboldtii*, and of *M.* [=*Cordillerion*] *andium*, reproduced above (Fig. 495) from Boule's Memoir of 1920, display in a most convincing manner the profound structural and phylogenetic differences between the crania of *Cuvieronius* and *Cordillerion*. While the *Cuvieronius* skull converges toward that of *Elephas* and of *Mastodon americanus*, the *Cordillerion* skull retains the relatively low, simple character of the primitive Trilophodonts. We may be sure that the favorite plant foods and the feeding habits of *Cuvieronius* differed as widely from those of *Cordillerion* as do the crania from each other.

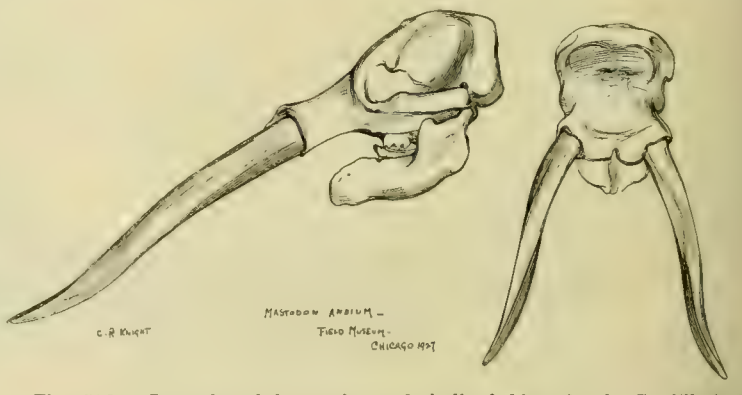
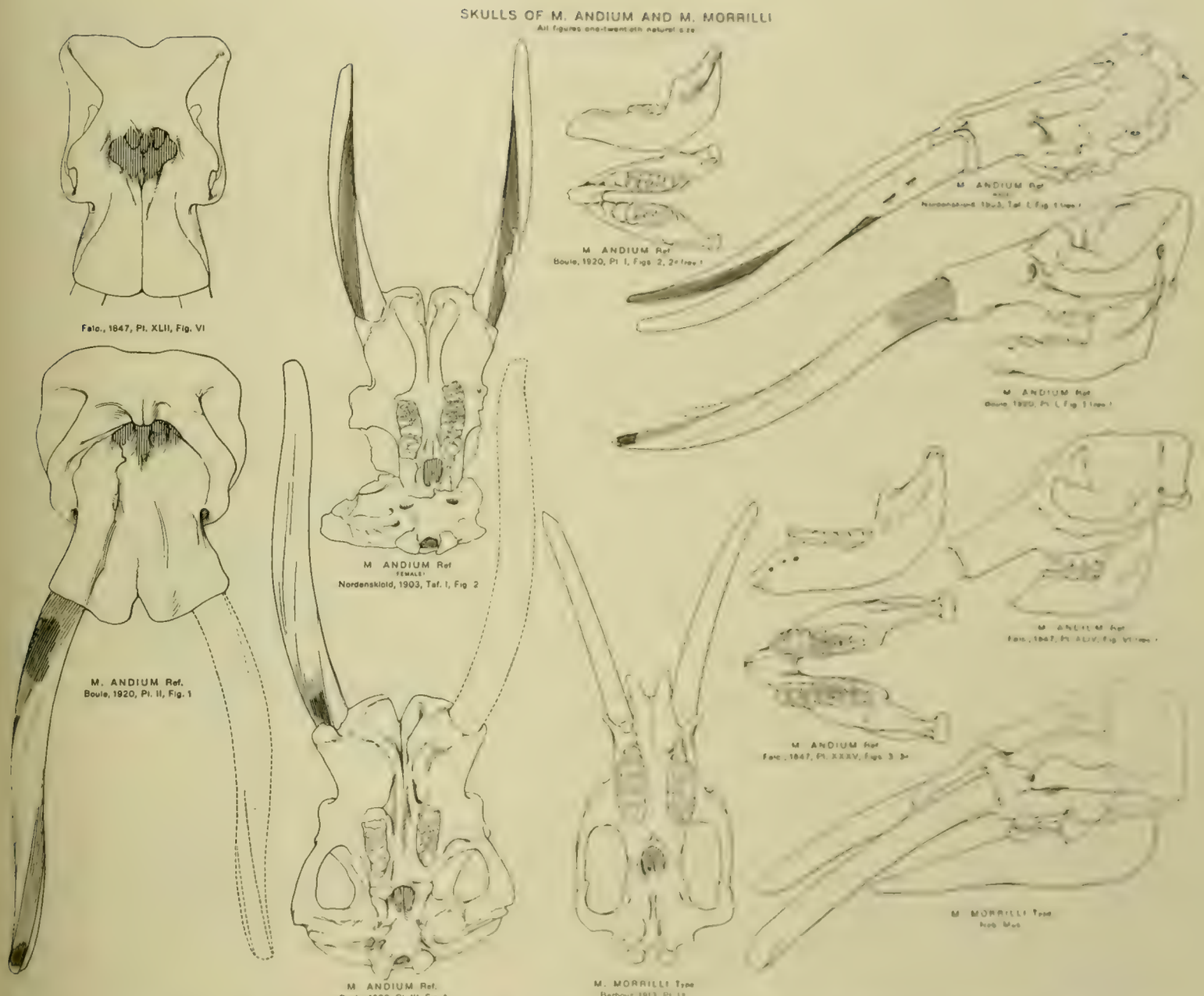


Fig. 506. Lateral and front views of skull of *Mastodon* [=*Cordillerion*] *andium* in the Field Museum of Natural History, Chicago. After pen sketch by Charles R. Knight, 1927.

It is probable that the upturned tusks of *Cuvieronius*, lacking the enamel band, were used like those of the true *Mastodon* for offensive and defensive purposes and also to a certain extent in uprooting trees and pulling down limbs, like the tusks of *Elephas* and of *Loxodonta;* this less effective type of *Cuvieronius* tusk is correlated with a more complex type of grinding teeth and with double trefoils. On the other hand, the downcurved and spiral tusks of *Cordillerion*, with their broad persistent enamel band, were kept constantly sharpened and were continuously of use not only for purposes of offense and defense but as an auxiliary in feeding; this more effective type of *Cordillerion* tusk is correlated with a more simple type of grinding teeth and with single trefoils.

W. D. Matthew, September, 1920; Stockholm Museum.—The two skulls from Tarija in the Stockholm Museum (described and figured by Nordenskiöld in 1903) are the most perfect known, designated as male and female. The two animals are about the same age, M^1 lost on one side, still present on the other; M^2 moderately worn; M^3 just coming into wear at the anterior end. The chief sexual difference is in the size of the skull and in the diameter of the tusks. The female tusks are shorter and more slender, and do not turn inward, but are about 27 inches apart throughout their distal half. The enamel band begins on the outer side of the tusk, twists around underneath, and ends on the inner side, partly above the tip of the tusk; in lateral view the tusks are almost straight, curving slightly upward at the tips; from above they are lyrate, about 18 inches apart at the base, 30 inches at two-fifths distance from the socket, 15 inches at the tip, where they turn and go parallel. The width of the enamel band is about 3 inches in the male, 2½ inches in the female. The tip of the tusks is most worn on the lower surface and is evidently partly protected by the enamel band but not wholly.



CRANIA OF M. ANDIUM [=CORDILLERION], OF M. HUMBOLDTII [=CUVIERONIUS], AND OF M. MORRILLI [=EUBELODON]

Fig. 507. Skulls and jaws of the finely preserved specimens of *Mastodon* [=*Cordillerion*] *andium* in the Museums of Stockholm and Paris and of *Eubelodon morrilli* in the Nebraska Museum. Compare Falconer, 1846 [1847], Nordenskiöld (1903), and Boule (1920). The species *C. andium* is remarkable for the spiral twisting of the superior tusk on its own axis, so that the enamel band in aged individuals makes a complete circuit of the tusk (see Boule, 1920, Pl. II, fig. 1). The upper left-hand cranium is referred to *Cuvieronius humboldtii*.

The type (Neb. Mus. 1-16-5-13) of the species *Eubelodon morrilli* (erroneously appearing as *M. morrilli* on the plate) is said to entirely lack the enamel band. The type of the species *Mastodon* [=*Stegomastodon*] *successor* Cope is also said to lack the enamel on the associated superior tusks.

Among other specimens referred to *Cordillerion andium*, very young jaws exhibit a distinctly small pair of tusks in the male, but no tusks in the female.

W. D. Matthew, September, 1920; Berlin.—In the Berlin Museum (für Naturkunde) one of the jaws referred to *Cordillerion andium* is very large, equaling an *M. americanus* in size. There are no lower tusks; the upper tusks are straight, round, parallel with each other, and with the same spiral twist as those in the Stockholm skulls.

W. D. Matthew, September, 1920; Paris, Jardin des Plantes.—Here are skulls referred to *Mastodon humboldtii*, all from the Pampean, and of *Mastodon andium*, the latter specimen with well-preserved feet; also many jaws and fragments showing a wide range of individual variation (auct. Boule). The *C. andium* material is all from the valley of Tarija in Bolivia.

Progressive Characters of Cordillerion

In all, fifteen species of *Cordillerion* have been named, including the apparently undefined *Mastodon tarijensis* of Ameghino, also the *Anancus orarius* and *A. defloccatus* of Hay and the *Anancus bensonensis* of Gidley which the present author has transferred to the genus *Cordillerion*. In time we shall doubtless be able to arrange these animals in approximate ascending phylogenetic order; at present this can only be done tentatively.

Ridge Formula.—The only progressive character thus far observed is in the *crest addition* at the posterior end of the second and third superior and inferior molars. The more *primitive* species apparently are those which possess but 4+ crests in M_3, corresponding with the four-crested condition in *Trilophodon*. The more *progressive* species are those in which 5+ crests are observed in the posterior molars, and an extra crest in M_2. A second progressive character is the addition of a fourth crest to the second inferior molars, a stage attained in the genus *Tetralophodon* but not in *Trilophodon*. Arranging the species simply on the principle of progressive crest addition, they appear in descending order as follows:

(A) Species with 5+ crests on the third inferior molars, M_3.

Cordillerion bolivianus, Ulloma, Bolivia.
Cordillerion tropicus of Mexico.
Cordillerion oligobunis progressus, Canyon of Aculcingo, Mexico.
Cordillerion orarius, near Sinton, Texas
Cordillerion defloccatus, near Sinton, Texas.
[*Teleobunomastodon* [=*Cordillerion*] (?)*bolivianus* ref., Bolivia; M^3 with 5-6 ridge-crests.]

(B) Species with 4+ crests on the third inferior molars, M_3.

Cordillerion andium, i.e., specimens from Tarija, Bolivia.
Cordillerion tarijensis of Tarija; probably a synonym of *C. andium*.
Cordillerion oligobunis of Mexico.
Cordillerion(?) *oligobunis felicis*, Puebla, Mexico.
Cordillerion(?) *oligobunis intermedius* of Mexico.
Cordillerion gratum, Burleson County, Texas.
Cordillerion edensis, Mt. Eden Hot Springs, California.
Cordillerion bensonensis, near Benson, Arizona.

(C) Of uncertain reference.

Cordillerion andium kraglievichii, description and figures not available to present author.
Cordillerion oligobunis antiquissimus, third molars inadequately described.

Proportions of Third Molars. In a careful comparison of the grinding teeth in the type and referred figures of the above species, it will be observed that following the usual law of molar evolution the third inferior molar is more progressive, that is, longer and narrower, invariably exhibiting a fourth full crest or tetar-

tolophid. The upper molar, M^3, is invariably broader than its mate below, M_3. If we compare the specific stage *Cordillerion oligobunis* (Fig. 514) with the type of *C.(?) oligobunis felici* (Fig. 516) and finally with the Tarija specimens referable to *C. andium* (Fig. 504) or the doubtful *C. tarijensis*, we observe the amount of progression in the development of the tetartoloph and tetartolophid in M^3-M_3, also in the addition of a tetartolophid in M_2.

Consequently it is only a matter of time and of closer monographic research when we shall be able to arrange the species of *Cordillerion* in their approximately true phylogenetic order.

SOUTH AMERICAN SPECIES

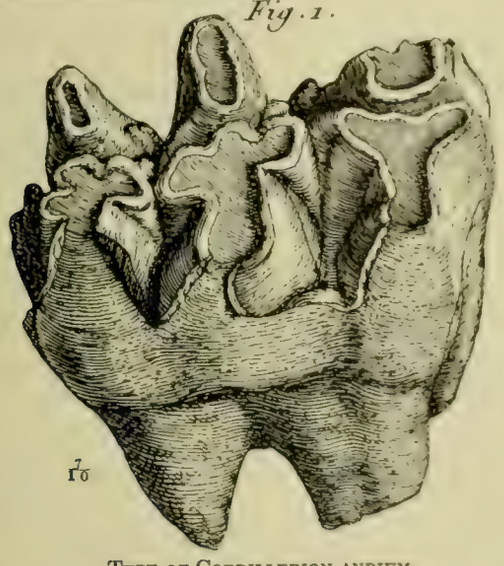
Cordillerion andium Cuvier, 1806, 1824

Figures 79, 484, 486, 488, 495, 496, 498, 502–504, 508, 509, 528, 529

Pleistocene. Found by von Humboldt near the volcano of Imbaburra, Quito, Ecuador, at an elevation of 1200 toises (=about 7,673 feet).

Syn.: *Mastodonte des Cordilières* Cuvier, 1806; *Mastotherium hyodon* Fischer, 1814; *Mastodon cordillerarum* Desmarest, 1822: *Mastodon Andium* Cuvier, 1824; *Mastodon Antium* Burmeister, 1889. A possible synonym is *Mastodon tarijensis* Ameghino, 1902.

Fig. 1.



TYPE OF CORDILLERION ANDIUM

Fig. 508. Original type figure of "*Mastodonte des Cordilières*" Cuvier, 1806.3, Pl. 67 (II), fig. 1 = *Mastodon andium* Cuvier, 1824. A second molar. About seven-tenths natural size. From near the volcano of Imbaburra, Quito, Ecuador. This type belongs in the Muséum d'Histoire Naturelle, Paris, but could not be located for the writer during his visit of 1921; an r.M^2.

Cuvier's type of the *Mastodonte des Cordilières*, reproduced in facsimile (Fig. 508) from Cuvier, 1806.3, Pl. 67 (II), fig. 1, and confirmed by de Blainville, 1839–1864, p. 249, is recorded as from near Quito, Ecuador, whereas his type of the *Mastodonte humboldien* is from near Concepcion, Chile [?Ecuador]. Cuvier distinguished this animal from the *Petit mastodonte* (=*Turicius tapiroides*), from the *Mastodonte à dents étroites* (=*Trilophodon angustidens*), and from the *Mastodonte de l'Ohio* (=*Mastodon americanus*).

We may reproduce in full Cuvier's original description:

"*Mastodonte des Cordilières*, la grande à dents carrées," Cuvier, 1806.3, p. 413 (=*M. cordillerarum* Desmarest, 1822, p. 385; =*Mastodon Andium* Cuvier, 1824, Vol. V, Pt. 2, p. 527). "Sur Différentes Dents du Genre des Mastodontes," Ann. Mus. d'Hist. Nat., 1806, Vol. VIII, p. 411–413. TYPE.—A second molar, r.M^2. HORIZON AND LOCALITY.—Pleistocene. Near the volcano of Imbaburra, Quito, Ecuador, at an elevation of 1200 toises (=about 7,673 feet). TYPE FIGURE.—Cuvier, 1806.3, Pl. 67 (II), fig. 1; confirmed by de Blainville (1839–1864, p. 249).

TYPE DESCRIPTION.—(Cuvier, 1806.3, p. 411): "Les plus grandes ont les mêmes dimensions que leurs correspondantes de l'*Ohio*. M. *de Humbold* en a rapporté une qu'il a trouvée près du volcan d' *Imbaburra*, au royaume de *Quito*, à 1200 toises de hauteur. Elle est assez décomposée et encore enduite de cendres volcaniques. Son émail est teint en roussâtre; elle est longue de 0,12, et large de 0,085. Voyez pl. II [67], fig. 1."

DE BLAINVILLE, 1839–1864, p. 249.—"Cette espèce a été proposée, pour la première fois, par M. G. Cuvier, en 1806, dans son mémoire sur différentes dents de Mastodontes. Ann. du Mus., tome VIII, p. 411, et dans les mémoires réunis tome I, p. 11 [tome II, 1812, p. 11], et enfin dans la seconde édition de ses Recherches sur les Ossements fossiles de Quadrupèdes (tome I, p. 266, 1821 à 1825). Elle ne reposait et ne repose encore que sur un petit nombre de pièces, trois dents molaires. (*Loc. cit.*, pl. 2, fig. 1 et fig. 12.)"

SINGLE TREFOILS.—As narrated in the history of discovery above, Cuvier's definition of this animal as possessing molar teeth with *single* trefoils, confirmed by de Blainville, is sharply demonstrated in the type specimen (Fig. 508) and is further abundantly confirmed in two other teeth referred by Cuvier to this species; also in the superb teeth collected in Tarija, Bolivia, figured by Gervais in 1855 and reproduced in facsimile in our figure 504. The same figure shows the very sharp contrast with corresponding teeth of *Cuvieronius humboldtii*,[1] also after figures by Gervais, 1855. In all the figures referred in this Memoir to the genus *Cordillerion*, the *single* trefoils are very sharply defined and there is seldom a rudiment of the double trefoils.

SKULL.—The cranial characters displayed in the above collective figure (Fig. 507), reduced to the same scale from the plates of Falconer (1846, 1847), Nordenskiöld (1903), and Boule (1920), are very uniform, except that the *M. andium* of Falconer (1847) exhibits an abbreviated jaw. The best profile of the cranium and jaw is that of Boule (1920, Pl. I, fig. 1) showing the depressed character of the occiput and the elongated character of the rostrum. It will be observed that the typical rostrum as figured by Boule consists of an elongated trough similar to the rostrum figured by Falconer (1847, Pl. XXXV, figs. 3, 3a). This elongated rostrum appears also in the jaw figured by D'Orbigny (1842) reproduced in our figure 509, as well as in the jaw figured by Pompeckj (1905) and referred by him to the *Mastodon bolivianus* of Philippi, reproduced

[1]Referred in the present Memoir to *Cuvieronius (?) platensis*.

in our figure 512. Thus these various specimens agree in the elongate character of the rostrum with typical median groove, exactly comparable to the rostrum shown in the type figure of *Mastodon bolivianus* Philippi, reproduced in our figure 547.

Tusks and Grinders. Cordillerion andium.—Gervais (1855), from the Weddell collection of Tarija, calculates the length of two tusks, one approaching 2 m. (=6 ft., 6¾ in.), the other surpassing 2 m. 20 cm. (=7 ft., 2⅝ in.). Of the size of the third

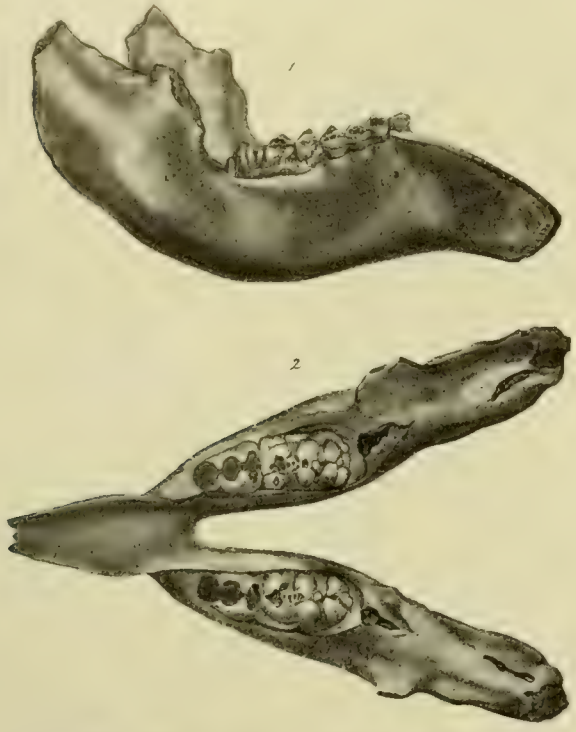


Fig. 509. Referred jaw of *Cordillerion andium*, one-ninth natural size. After D'Orbigny, 1842, Pl. x, figs. 1, 2. Original from Tarija, Bolivia. The specimen is probably in the Muséum d'Histoire Naturelle, Paris, but could not be located for the writer during his visit of 1921. The teeth in place are apparently M_1, M_2, both trilophodont with single trefoils, thus agreeing with the type of *Mastodon andium* figured above. This figure was reproduced by Philippi (Fig. 547,1) in his description (1893) of *M. bolivianus*.

inferior grinding teeth, reproduced from Gervais, 1855, Pl. v, figs, 7, 8 (our Fig. 504 above), he remarks (*op. cit.*, p. 21): "*e.* La *sixième molaire inférieure* (fig. 7 et 8) a quatre fortes collines transversales, multimamelonnées, et en arrière un fort talon composé de deux ou de plusieurs petits tubercules; . . . La couronne de la sixième molaire inférieure présente habituellement une plus forte couche de cément que celle des autres dents. . . . La longueur de cette dent varie, suivant les sujets, entre 0,16 et 0,19. Cette longueur diminue comme pour les autres molaires, lorsque le bord antérieur a été entamé par l'usure." He refers to this animal as "Mastodonte des Andes."

Absence of Specific Distinctions.—It is impossible without detailed monographic comparison of the types to determine the degree of separation from *Cordillerion andium* of the species subsequently described. Consequently we give in brief the definitions by Ameghino and by Philippi and quote in full also the comments by Boule

Notiomastodon argentinus Ameghino, 1888

Figures 491, 510, 531, 557, and 581a

Pliocene. Valley of Tarija River, northern part of Republic of Argentina; exact locality not recorded.

Osborn (1933) refers this type (see p. 592) to the genus *Notiomastodon* Cabrera, 1929; (1934) to the subfamily Serridentinæ (see p. 615 below); (1935) to the Notiomastodontinæ subfam. nov. (see Appendix to present Vol. I).

This species was found in a river valley of Argentina which heads up into the mountains of Bolivia and in the famous locality repeatedly explored on the Tarija River. Boule (1920, p. 68) regards *Mastodon argentinus* as an ancestral form of *Mastodon andium* Cuvier: "Le *M. argentinus* rappelant assez les Mastodontes miocènes d'Europe par la forme et la longue bande d'émail

Defensa de *Mastodon argentinus* $^1/_{10}$ del tamaño natural

Type of Notiomastodon argentinus

Fig. 510. Type superior tusk of *Mastodon argentinus* Ameghino, 1888, with broad enamel band. After Ameghino, 1889, p. 644, one-tenth natural size. This tusk may be *inverted* (cf. Figs. 489–492, p. 520, of the present Memoir).

de ses défenses, on pourrait supposer qu'il représente une forme ancestrale du *M. andium*. Mais l'age exact de son gisement est inconnu." The perfectly straight lateral enamel band of '*Mastodon*' *argentinus* clearly distinguishes this species from *Cordillerion andium* which is characterized by a spiral enamel band. Philippi observes (1893) that *M. argentinus* is distinguished by thin, almost straight incisive tusks; he does not mention the enamel band.

Ameghino's original description may be cited as follows:

Mastodon argentinus Ameghino. Rápidas Diagnosis, 1888, p. 7. Type.—Superior tusk; present location unknown. Horizon and Locality.—"Salta y valle de Tarija." Exact locality unrecorded. Type Figure.—Ameghino, 1889, p. 644 (text figure); also supplementary description.

Type Description.—(Ameghino, 1888, p. 7): "Muelas sobre el mismo tipo que las de *Mastodon andium*, pero la talla del animal dos quintos mas pequeña.—Axis de 180 mm. de diámetro transverso, en la cara anterior, y 255 mm. de largo de la apófisis espinosa á la parte inferior del cuerpo.—Fémur delgado, de 60 ctm. de largo.—Cúbito de 50 ctm. de largo.—Húmero de 59 ctm. de largo, 21 ctm. de diámetro máximo en la extremidad proximal, y 16 ctm. de ancho en la distal.—Procedencia: Salta y valle de Tarija."

Cordillerion tarijensis Ameghino, 1902

Valley of Tarija, Bolivia.

This mastodont of Tarija appears to be a name only; neither original description nor figure is known to us at present. The specific name *tarijensis* is probably a synonym of *Cordillerion andium*.

Mastodon tarijensis Ameghino, 1902. "Cuadro Sinóptico de las Formaciones sedimentarias, Terciarias y Cretáceas de la Argentina en relación con el Desarrollo y Descendencia de los

Mamíferos." An. Mus. Nac. de Buenos Aires, Tome I [VIII], Ser. III, p. 2.

Ameghino, 1902.2, p. 2.—"Formación Araucana. Puelche. Arenas subpampeanas de la región bonaerense, depósitos inferiores de Tarija, etc., con Mastodon tarijensis, Nopachtus coagmentatus, Sclerocalyptus cordubensis, etc."

Pompeckj, 1905.—Pompeckj in his article "Mastodon-Reste aus dem interandinen Hochland von Bolivia," Palaeontographica, 1905, Band LII, p. 52, remarks as follows:

"Nach dem Erhaltungszustande der Fossilien und nach der Zusammensetzung der Fauna nimmt Ameghino . . . an, dass in Tarija zwei verschiedene Horizonte seines Pliocän vertreten seien, das 'Ensenadense' und 'Bonaerense.' An anderer Steile . . . setzt Ameghino seine untere Schicht von Tarija mit *Mastodon tarijensis* (doch wohl = *Mast. Andium*) in das 'Puelche,' d. h. in sein allerunterstes Pliocän. Nordenskjöld konnte trotz lokal verschiedener Beteiligung einzelner Arten an der Zusammensetzung der Fauna von Tarija keine Trennung nach verschiedenen Horizonten feststellen; . . . er nennt die Fauna pleistocän. . . . Das stimmt überein mit dem Ergebnis der Studien Brancos . . . über die der tarijenser Fauna gleichkommende Säugerfauna von Ecuador, welche beiden Faunen eher pleistocän als pliocän sind. Steinmann hält die Fauna von Tarija und die von Ulloma für 'unserem Mittelquartär (älterer Löss') entsprechend."

Osborn, 1926: This species is probably a synonym of, or closely related to, *Cordillerion andium*. The name *M. tarijensis* occurs in Ameghino's Synopsis of 1902 and is cited by Pompeckj in 1905; Osborn is unable to find either the original description or figure of this species, consequently for the present the name only is cited.

Cordillerion bolivianus Philippi, 1893

Figures 512 and 547

Ulloma, Bolivia, 3,800 m. above the sea, nine leagues to the south of the famous copper works of Corocoro. Pleistocene.

Mastodon bolivianus Philippi, 1893. "Vorläufige Nachricht über fossile Säugethierknochen von Ulloma, Bolivia." Zeits. Deuts. geol. Ges., Band XLV, 1893, p. 89. Type.—Lower jaw. Horizon and Locality. Ulloma, Bolivia, 3,800 m. above the sea, nine leagues to the south of the famous copper works of Corocoro. Type Figure.—*Op. cit.*, p. 89, fig. 2. (Fig. 547, 2, of the present Memoir.)

The imperfect and juvenile *type* jaw of *Mastodon bolivianus* Philippi (Fig. 547, 2) may belong to the genus *Cordillerion*, but the adult lower jaw *referred* to this species by Pompeckj in 1905 (Fig. 512) exhibits one of the distinctive characters of *Cuvieronius humboldtii*, namely, in the possession of five and a half ridge-crests in the third inferior molars. Consequently the generic reference of this species is somewhat uncertain. In comparing M_3 (Fig. 512) with M_3 (Fig. 504), it is difficult to make out whether these teeth possess *single* or *double* trefoils; single trefoils would relate it to *Cordillerion*. The species '*Mastodon*' *bolivianus* is distinguished by Philippi from '*Mastodon*' *andium*, as shown in figure 547, figs. 1–3, reproduced directly after Philippi. Figure 1 is considered by Philippi as the long delicate rostrum of the lower jaw characteristic of *M. andium*, while figure 2 is regarded as the relatively broad rostrum characteristic of the new species *M. bolivianus*. Careful examination of Philippi's text does not reveal more than this type figure (Fig. 547, 2) with name, whereas in the same article '*M.*' *chilensis* is fully described, as cited below under the genus *Cuvieronius*.

Associated Fauna (Philippi, 1893, pp. 87-94).—Its associated remains include *Hippidion bolivianum* sp. nov., *Megatherium Medinæ*, and *Megatherium Sundti*, an edentate related to the *Scelidotherium*. Of the climatic environment and flora Philippi

Fig. 511. Cordillerion (?) bolivianus Rlf.

Genotype third left superior molar, l.M^3, of *Teleobunomastodon bolivianus* Revilliod, 1931, in the Muséum d'Histoire naturelle de Genève (Mus. Genève 817/74). After Revilliod, 1931, fig. 3, p. 9; "Sixième molaire supérieure gauche, face externe de Mastodon bolivianus (Muséum de Genève); 1, 2, 3, 4, pointes externes des quatre lobes antérieurs; 5 et t, talon. Red. ½." One-half natural size. Five and a half ridge-crests, surrounded at the base with cement. Reversed to show natural position.

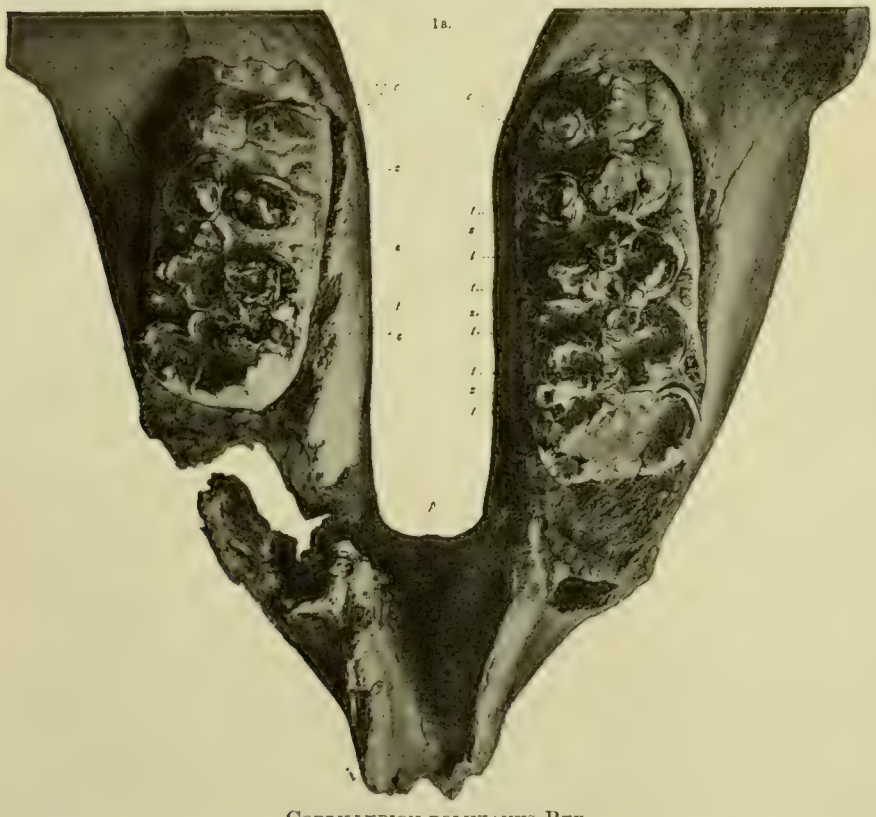
observes (*op. cit.*, 1893, p. 95): "Vielleicht kann man annehmen, dass zwar bereits zu Anfang der Diluvialzeit Höhen, Berge und Rücken existirten, von denen das ungeheure Material der Pampasformation herabgeschwemmt und herabgeweht worden ist, dass aber diese Erhebungen zu unbedeutend waren, um einen grossen Einfluss auf das Klima auszuüben, so dass die grossen Megatherien, Mastodonten etc. eine reiche, für ihre Ernährung geeignete Vegetation fanden, dass aber dann eine grosse Katastrophe eingetreten ist, welche die gedachten Berge zu ihrer jetzigen Höhe erhoben, und zugleich dem derzeitigen organischen Leben ein Ende gemacht hat, um der jetzigen Schöpfung Platz zu machen."

Climatic Conditions (Pompeckj, Palaeontogr., 1905, p. 54).—Pompeckj observes that the climatic conditions in the highlands of Bolivia were very different in '*M.*' *bolivianus* times from the present; the rainfall was greater. On the west side of the Cordillera the glaciers descended 1,000 m. deeper than today (circa 5,300 m.) In the western portion of the highlands flat basin-like depressions were filled with layers shed by numerous streams and rivers, perhaps also through æolian agencies. The referred jaw figured by Pompeckj, from Ulloma, shows a five-crested M_3 *in situ*, and a relatively abbreviated symphysis as compared with the figure of a young jaw, with M_2, M_3 *in situ*, given by Philippi.

Boule, 1920, p. 68.—"*Mastodon bolivianus*, d'Ulloma (Bolivie), décrit sommairement par Philippi et plus longuement par Pompeckj, est caractérisé surtout par la largeur, la brièveté, la courbure brusque de la gouttière symphysaire, la présence de traces de petites alvéoles divergentes pour les défenses inférieures, l'existence

de saillies en forme de lèvres à la face inférieure de la symphyse et d'une légère apophyse pour le génioglosse à la face interne. Ce sont là en partie des différences individuelles, en partie des caractères sexuels. Le *M. bolivianus* est vraisemblablement un mâle de *M. andium;* tout au plus pourrait-on admettre, en raison de sa grande taille et de l'altitude considérable de son gisement (3,800 m.), qu'il s'agit d'une race locale. . . . "

Osborn, 1926: The presence of five and a half ridge-crests on the third lower molar of the referred jaw (Fig. 512, after Pompeckj) indicates a more progressive third inferior molar stage than that of the specimen from Tarija figured by Gervais (Fig. 504,8). Boule is undoubtedly right (1920, p. 68) in saying that *M.* [=*Cordillerion*] *bolivianus* probably represents a broad-jawed male individual of large size, perhaps adapted to lofty altitudes.



CORDILLERION BOLIVIANUS REF.

Fig. 512. Referred lower jaw of *Mastodon bolivianus* Philippi, 1893, one-third natural size. After Pompeckj, 1905, Pl. III, fig. 1a. Observe the five and a half ridge-crests, apparently with single trefoils, on l.M_3. These 5+ ridge-crested molars closely resemble in size those of *Cordillerion tropicus* Cope (Fig. 513).

TELEOBUNOMASTODON(?) REVILLIOD, 1931, BOLIVIANUS =CORDILLERION(?) BOLIVIANUS REF.

Figure 511

Exact locality not known, but probably from the vicinity of Calacoto, valley of the Rio Desaguadero, Bolivia, 5 km. south of Corocoro, or from Concordia, northeast of the mouth of the Mauri River.

Teleobunomastodon Revilliod, 1931, *bolivianus* Philippi, 1893. Revilliod, "Sur un Mastodon de Bolivie," Mém. Soc. Paléont. Suisse, Vol. LI, pp. 1–21, Pls. I, II, text figs. 1–9. TYPE.—Cranium, mandible, and various skeletal parts, in the Muséum d'Histoire naturelle de Genève (Mus. de Genève 817/74). HORIZON AND LOCALITY.—From the Quaternary terraces along the river Desaguadero on the high plateau of Bolivia. TYPE FIGURE.—*Op. cit.*, Pls. I, II, and text figure 3 especially.

Revilliod (1931, pp. 20, 21) selects *Mastodon bolivianus* Philippi as the genotypic species of his new genus *Teleobunomastodon*, resting it on "une forme terminale d'un des nombreux phylums de Mastodontes . . . le proboscidien du Rio Desaguadero serait le dernier terme des Mastodontes bunolophodontes à trèfle simple et à bande d'émail sur les défenses supérieures. Nous proposons la dénomination générique de *Teleobunomastodon.*"

(Letter, Revilliod, Jan. 6, 1932) Revilliod amplifies his definition as follows: "Le nom de genre *Teleobunomastodon* se rapporte à cette espèce nommée *bolivianus* par Philippi dont l'esquisse a montré qu'elle se distinguait du *M. andium* par le bec de la mandibule, plus court, plus large et à bords parallèles. Il se trouve donc dans les alluvions du Rio Desaguadero aux environs d'Ulloma, une seule et même espèce dont Philippi a montré le caractère le plus typique de la mandibule. . . . Le *Teleobunomastodon bolivianus* est un mastodon à bande d'émail sur les défenses, dont les M^3 et M_3 sont caractérisées par leur long talon, l'usure en trèfle simple, les collines très hautes et serrées. Le *Teleobunomastodon* est un genre très évolué dans le sens proboscidien, à caractères extrêmes: redressement de la base du crâne, raccourcissement de la mandibule, aplatissement de la défense."

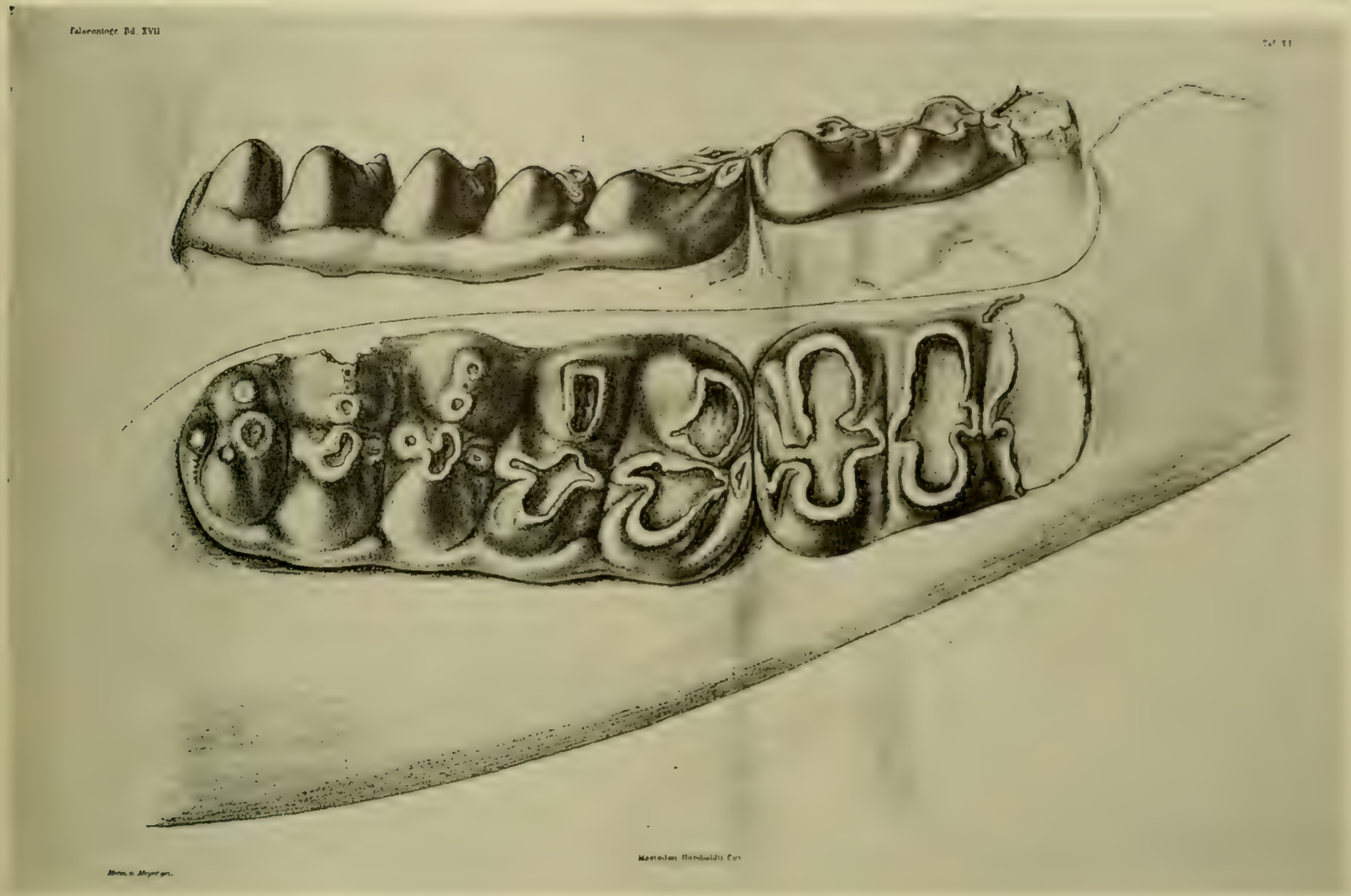
Osborn (1933[1]) regrets that the generic name *Teleobunomastodon* Revilliod, 1931, cannot be adopted, because the definition rests upon a *referred* specimen in the Muséum de Genève which differs widely from Philippi's type (Fig. 547, 2). In this referred specimen the third superior molar (Fig. 511), with cement and lofty subhypsodont 5½ ridge-crests, resembles the corresponding tooth (r. M^3) of *Cuvieronius platensis* (Fig. 560) figured by Cabrera, and is quite different from the typically low-crowned third superior molar of *Cordillerion;* we are inclined to regard it (1) with enamel band, (2) with single trefoils, (3) with lofty cones and cement (cf. Revilliod, 1931, p. 20) as distinct from *bolivianus*, and as more progressive than *Cordillerion*(?) *oligobunis felicis* Freudenberg described below.

Of the skull, jaw, and molar tooth fragments (Mus. de Genève 817/74) the most characteristic is a third superior molar, l.M^3 (Pl. I, fig. 5, text fig. 3, p. 9) reproduced herewith as figure 511. The ramus (Pl. II, figs. 1–6) is widely different from the rostrum in Philippi's type (Fig. 547, 2) and agrees more closely with the normal '*M.*' *andium* mandible (Fig. 547, 1) than with that of '*M.*' *chilensis* Fig. 547, 4).

MEXICAN SPECIES REFERRED TO CORDILLERION

In the history of discovery (p. 533) is given a full account of the confused and almost baffling names applied to Notorostrines of Mexico, as described by Cope (1884, 1893), by Felix (1891), by Villada (1903), and by Freudenberg (1922). It is also pointed out that since only two bunomastodonts have been discovered in Mexico, namely, *Rhynchotherium* and *Cordillerion*, both genera

[[1]This was one of the questions that Professor Osborn intended to reconsider; he evidently doubted the reference of Revilliod's "*bolivianus*" even to *Cordillerion* and hints that it may be a more progressive species than "*Cordillerion*(?) *oligobunis felicis.*"—Editor.]



TYPE OF CORDILLERION TROPICUS COPE, AFTER VON MEYER'S 'MASTODON HUMBOLDTI' REF.

Fig. 513. Right lower grinding teeth, M_2, M_3, one-half natural size. Figured by von Meyer as *Mastodon Humboldti* (von Meyer, 1867, Pl. VI); selected by Cope (1884.2) as the *type* of the new species *Dibelodon tropicus*. Collected by Uhde in the State of Michoacan, Valley of Mexico; original now in the Geological Institute of the University of Breslau with the Uhde collection. This animal appears to be in a similar stage of evolution to that of the type of *Cordillerion bolivianus* Philippi (Fig. 547) and to the trilophodont type of *Cordillerion andium*.

exhibiting *single* trefoils, it is only possible to distinguish *Cordillerion* by its relatively *narrower* grinding teeth and *Rhynchotherium* by its relatively *broader* grinding teeth, e.g., *Rhynchotherium browni*, broader third inferior molar, M_3, breadth-length index 55, *Cordillerion tropicus*, narrower third inferior molar, M_3, breadth-length index, 44. In the case of the four subspecies described by Freudenberg below, it is somewhat difficult to determine whether they are all referable to *Cordillerion;* as compared with the upper and lower grinding teeth of *C. andium* from Tarija, Bolivia, it appears that these four Mexican subspecies represent a more *primitive* stage than either *C. andium* or *C. tropicus*.

The Mexican species certainly referable to *Cordillerion* are:

Cordillerion tropicus Cope, 1884
Cordillerion oligobunis Cope, 1893

The Mexican subspecies probably referable to *Cordillerion* are:

Cordillerion oligobunis antiquissimus Freudenberg, 1922
Cordillerion(?) *oligobunis felicis* Freudenberg, 1922
Cordillerion(?) *oligobunis intermedius* Freudenberg, 1922
Cordillerion oligobunis progressus Freudenberg, 1922

Cordillerion tropicus Cope, 1884

Figure 513

Pliocene or Pleistocene. State of Michoacan, Valley of Mexico.

HISTORY.—In 1867 Herman von Meyer described (p. 64) and figured (Taf. VI) as '*Mastodon Humboldti*' a right ramus of a jaw containing the second and third inferior molar teeth, collected in the State of Michoacan, Valley of Mexico: "Mastodon Humboldti Cuv.? In der Sammlung Mexicanischer Alterthümer, welche Herr Uhde während seines längeren Aufenthaltes in Mexico bemüht war zusammenzubringen, und die er, aus Amerika zurückgekehrt, in Handschuchsheim bei Heidelberg aufstellte, fand ich im Jahre 1840, wo ich diese wichtige Sammlung kennen lernte, neben einigen anderen Versteinerungen die von mir Taf. VI. Fig. 1 von aussen und Fig. 2 von oben abgebildete rechte Unterkieferhälfte von einem

Mastodonten, welche im Mexicanischen Staate Mechoacan in einer Höhe von ungefähr 2500 Fuss über dem Meere gefunden wurde. Dieses Kiefers gedachte ich bereits in einer kurzen Uebersicht, die ich im Jahrbuche für Mineralogie (1840.S.576) von der Uhde'schen Sammlung gegeben habe."

Although these teeth (Fig. 513) with their single trefoils were obviously similar to those of '*M.*' *andium* and not to those of '*M.*' *humboldtii*, von Meyer referred them, with figure, to *M. humboldtii* (*vide* von Meyer, 1867, Pl. VI). In 1884 Cope (1884.2, p. 7) selected this very specimen and figured it as the *type* of a new species, *Dibelodon tropicus*. In 1892–1893, in the collection from the Upper Pliocene Blanco formation of Texas, Cope also found a well-preserved left mandibular ramus which he figured (1893.1, Pl. XVI, figs. 1, 1*a*, and Pl. XVII, fig. 1) and *erroneously referred* to *Dibelodon tropicus;* comparison with Cope's type of *D. tropicus* proves that this referred jaw belongs to the genus *Stegomastodon*, first described by Cope (1892.2, p. 227) as *Mastodon successor*, a name which he subsequently withdrew (1893.1, p. 63) referring this jaw to *D. tropicus* as above stated; it is therefore revived in the present Memoir as Cope's type of *Mastodon* [=*Stegomastodon*] *successor* (see Chapter XIII, Fig. 641).

Dibelodon tropicus Cope, 1884. "The Extinct Mammalia of the Valley of Mexico." Proc. Amer. Phil. Soc., Vol. XXII, 1884 [Cope, 1884.2], p. 7 (printed October 21, 1884). TYPE.—Cope selects as his type the specimen which von Meyer describes as above (von Meyer, 1867, p. 64).

TYPE FIGURE.—Figured as *M. humboldti* by von Meyer in his article "Studien über das Genus Mastodon," Palaeontographica, 1867, Band XVII, Taf. VI.

HORIZON AND LOCALITY.—State of Michoacan, Valley of Mexico, Uhde Collection. Now in the Geological Institute of the University of Breslau.

TYPE JAW FROM MEXICO AND REFERRED MATERIAL FROM PERU.—(Cope, 1884.2, p. 7): "A second species of Dibelodon inhabited the valley of Mexico, of larger size than the *D. shepardi*, and differing somewhat in the dentition. Von Meyer describes and figures a ramus of a lower jaw, . . . brought by Herr Uhde from Mexico, which has, according to Von Meyer, no mandibular tusk, and probably a short elephantine symphysis. A very similar ramus, containing the last molar tooth, was presented to the Philadelphia Academy of Natural Sciences by Dr. Isaac Coates, who obtained it from Tarrapota, on the Huallaga river, in Eastern Peru. The extremity of the symphysis of this specimen is broken away, but enough remains to show that it was probably short, and that there was no inferior incisor. Reference to Von Meyer's figure shows that the last inferior molar has five well-developed cross-crests and a heel. The Peruvian specimen has the same character, the fifth cross-crest a very little more contracted than in Von Meyer's plate."

SPECIFIC CHARACTERS OF CORDILLERION TROPICUS.—(1) Intermediate molars, M_2, with three crests and external trefoils. (2) Last molar with five crests and a strong tubercular talon; fifth crest elevated but composed of only two main cones without trefoils. (3) External trefoils well developed on M_3. (4) Distinguished from *M. humboldtii* by the presence of *single* trefoils; in '*M.*' *humboldtii* they are double. (5) . . . "according to Von Meyer, no mandibular tusk, and probably a short elephantine symphysis."

Osborn, 1924: The above description by Cope distinguishes his type of *Dibelodon tropicus* from *Cuvieronius humboldtii* but not from *Cordillerion andium*, in fact, Cope observes that the molars of *Dibelodon tropicus* are like those of *Tetrabelodon andium*. Consequently the implied distinction from *D. andium* depends on the supposed absence of inferior incisors.

Cordillerion oligobunis Cope, 1893

Figure 514

Tequixquiac, Valley of Mexico (see also Freudenberg, 1922). Pliocene or Pleistocene (*fide* Furlong, 1925).

C.(?) *oligobunis felicis* Freudenberg, 1922 (cf. *Mastodon oligobunis oligobunis* in Hay, 1925.3).

(Furlong, 1925, p. 138): "The town of Tequixquiac lies north of Mexico City a distance of approximately thirty miles. . . . [p. 140] Tequixquiac, Zumpango, and the extensive area lying between these two towns are noteworthy for their productiveness of Pleistocene vertebrate materials. Proboscidian remains are particularly abundant. The collection obtained by the writer during the short time spent in this region consists of two fairly complete mandibuli, parts of two skulls, many dissociated teeth, some limb and foot bones, and many incomplete or fragmentary tusks that were difficult to preserve . . . the evidence showed that members of the *Proboscidea* were present in great numbers and apparently were among the very last of the Pleistocene fauna to become extinct. It is possible that the area represents the site of their latest survival on the continent."

The type of this species (Fig. 514) is apparently distinguished from the type of '*M.*' *tropicus* and of '*M.*' *bolivianus* by the presence of only four and a half ridge-crests in M_3; in which character it agrees with the specimens from Tarija (Fig. 504).

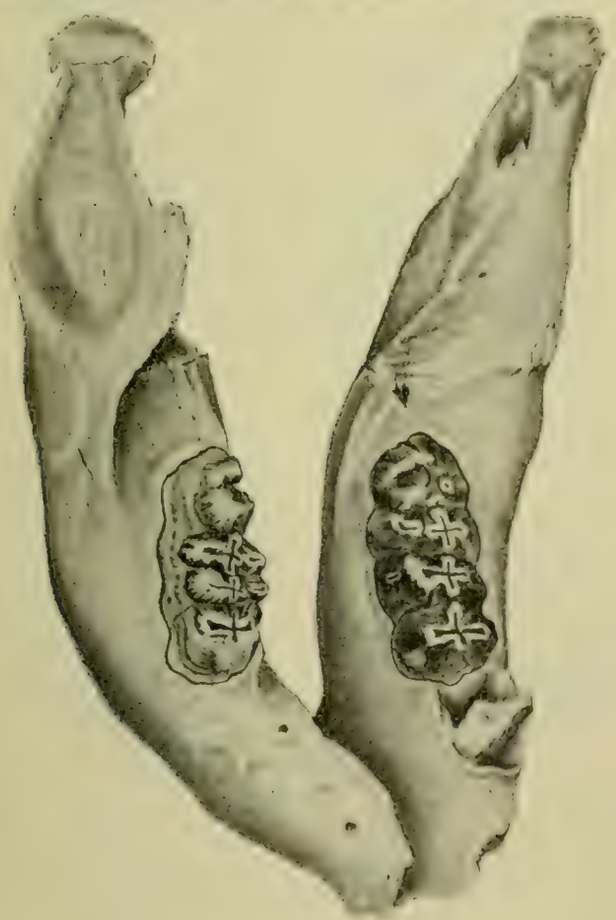
HISTORY.—Cope in 1884 examined and reviewed the specimens of Proboscidea contained in the Museo Nacional of Mexico, of which, under the erroneous reference to '*Dibelodon*' *shepardi* Leidy (1884.2, p. 6), he described "a well-preserved lower jaw [Fig. 514] of a Mastodon, which presents both rami, and both the last true molars, and the entire symphysis. . . . The molars have the characters of those of the *Mastodon andium* of authors, and are of about the same size. The cross-crests are divided at the middle line only, and one half wears into a trefoil, while the other half wears into an oval, transverse to the long axis of the crown. The unworn crests are obtuse and not serrate; and there are no accessory tubercles besides those forming the lateral lobes of the trefoils. . . . The last inferior and last superior molars have but four cross-crests and a small heel. . . . From these specimens it is clear that the high valleys of Mexico were inhabited by a trilophodont mastodon, with a short decurved toothless symphysis like that of the *Elephas primigenius*, and with a band of enamel on the superior incisor tusks. . . . In the character of its molars it is identical with the *M. andium*, and differs from the *M. humboldtii* in the characters which distinguish the two species, as pointed out by Gervais [Footnote: 'In Castelnau's Expedition, 1855; Recherches sur les Mammiferes Fossiles de l'Amerique Meridionale, p. 14.']. That is, only one-half of each cross-crest wears into a trefoil, and the size is inferior."

This lower jaw Cope originally referred (1884.2, pp. 5–7) to *Dibelodon shepardi* Leidy, but subsequently (1893.1, p. 59) he made it the type of a new species, namely, *Mastodon oligobunis*, the name *oligobunis* referring to the paucity of bunoid elements in the crown. The same type jaw was figured in Villada's Memoir of 1903, Lám.

VII, as "Mandibula inferior del *Dibelodon Shepardi*, Cope, (del tajo de Tequixquiac.)," one-third natural size, from which our figure (Fig. 514) is reproduced one-sixth natural size.

In 1903 Villada in his "Apuntes Acerca de la Fauna Fósil del Valle de México" reviewed the principal collections in the Museo Nacional of Mexico. In the section "Orden de los Proboscideos" (p. 450) he refers to Cope's type specimen as: "2° *Dibelodon*, Cope. Sin incisivos inferiores y los superiores con faja de esmalte. Tipo: *D. Shepardi*. . . . La especie de Tequixquiac es la que sirve precisamente de tipo al segundo de estos tres géneros. Otra que también le corresponde, es el *D. tropicus*, y de la cual tenemos como segura su presencia en la misma fauna; pero también con duda: la del *T. andium*, ó sea una especie del tercer género."

In 1893 Cope selected the jaw previously referred by him to *Dibelodon shepardi* Leidy as the type of the new species *Mastodon oligobunis*, the type description being as follows:



TYPE OF CORDILLERION OLIGOBUNIS

Fig. 514. Type lower jaw of *Mastodon oligobunis* Cope, 1893, in the collection of the National Museum of Mexico. After Villada, 1903, Lám. VII: "Mandibula inferior del *Dibelodon Shepardi*, Cope, (del tajo de Tequixquiac.)" One-sixth natural size. See also Freudenberg, 1922, p. 116, fig. 4.

Mastodon oligobunis Cope, 1893. "A Preliminary Report on the Vertebrate Paleontology of the Llano Estacado." Fourth Ann. Rept. Geol. Surv. Texas for 1892, p. 59. TYPE.—(Cope, 1884.2, pp. 5, 6): "The fossils of the Museum Nacional of Mexico, examined by me, included a well-preserved lower jaw [Fig. 514] of a Mastodon, which presents both rami, and both the last true molars, and the entire symphysis." HORIZON AND LOCALITY.—Tequixquiac, Valley of Mexico (see Cope, 1884.2, p. 1, also Freudenberg, 1922, p. 116). TYPE FIGURE.—Not figured by Cope. The type jaw of '*M.*' *oligobunis* Cope was figured by Villada in 1903, Pl. VII, under the original name "*Dibelodon Shepardi*, Cope." It was also figured by Freudenberg, 1922, p. 116, fig. 4, under the name *M. oligobunis*.

TYPE DESCRIPTION.—(Cope, 1893.1, p. 59): "This specimen [referred, not type, in School of Mines] came from Tehuichila, in the State of Vera Cruz, from a formation which I subsequently determined to be of Loup Fork age, so that the identity of the species with that found in the Equus beds of the valley of Mexico is highly improbable. I therefore refer the latter [i.e., the *type* from the Valley of Mexico] to the genus Mastodon under the specific name of *M. oligobunis*, Cope. It differs from the *Dibelodon tropicus* in the smaller number of cross-crests of the last molar, and their greater simplicity, since they are not divided at all, and the external halves of the first and second only have anterior and posterior buttresses, in some individuals at least."

Freudenberg (1922, p. 116) reproduces this same figure from Villada under the name: "Fig. 4. Unterkiefer vom *M. oligobunis* Cope von Tequixquiac, Mexiko. Original im Museo nac. Mexiko. D.-F. nach Villada [Footnote: 'M. Villada, Apuntes de la Fauna fosil del Valle de Mexico. Anales del Museo nacional Mexico. 1902. pag. 10–11.']." Freudenberg refers (p. 115, footnote) to Cope's paper "The Extinct Mammalia of the Valley of Mexico." While Freudenberg thus erroneously excludes Cope's type of *M. oligobunis* from relationship to *Mastodon andium*, Cope's original descriptions cited above (1884.2, pp. 5–7, and 1893.1, p. 59) leave no doubt that his type jaw of *Mastodon oligobunis* (Fig. 514) is closely related to *Cordillerion andium* and especially to the specimens from Tarija. The long narrow proportions of M_3, viewed in perspective in Villada's figure (Fig. 514), as well as the absence of inferior tusks, definitely relate this species to *Cordillerion* rather than to *Rhynchotherium;* there are apparently but four and a half ridge-crests in contrast with five and a half ridge-crests in '*M.*' *tropicus* and in '*M.*' *bolivianus*.

Osborn, 1924: Thus is cleared up the history of the type and the name of *Mastodon oligobunis* Cope, one of the most complicated in the whole literature of the Proboscidea. We trust that at last this type jaw, first referred to *Dibelodon shepardi* Leidy and then to *Mastodon oligobunis*, has now found a safe harbor and final retreat in the name *Cordillerion oligobunis*.

Cordillerion oligobunis antiquissimus Freudenberg, 1922

Figure 515

Pliocene. Valley of Amajaque, Hidalgo, Mexico.

This stage was proposed by Freudenberg as a primitive mutation or variety of *Mastodon oligobunis* Cope; the imperfect character of the type renders the determination somewhat doubtful. In the history of discovery above, the tortuous career of the specific name *Mastodon oligobunis* Cope is fully recited. We agree with Freudenberg that the present very fragmentary type from the State of Hidalgo resembles Cope's type of *Mastodon oligobunis*, which in this Memoir is shown to resemble very strongly *Cordillerion andium*, as Cope originally determined. Consequently this subspecies is transferred to the genus *Cordillerion*.

Mastodon oligobunis var. *antiquissima* nov. subsp. Freudenberg, 1922. "Die Säugetierfauna des Pliocäns und Postpliocäns von Mexiko. II. Teil: Mastodonten und Elefanten." Geol. und Palaeont. Abhand., N.F., Band XIV (Band XVIII), Heft 3, pp. 118–120. TYPE FIGURE.—Taf. IX, figs. 3 and 3a: "*Mastodon oligobunis* Cope var. *antiquissima* nov. subsp. No. 32 der Leihliste. Pliocän des Valle de Amajaque in Hidalgo. M_3 rechts unten."

TYPE DESCRIPTION.—(*Op. cit.*, p. 119): "Der letzte Mahlzahn vom Valle de Amayac kann ebenfalls nur 4 Joche und einen kleinen Talon besessen haben im Gegensatz zu den quartären Arten des *M. oligobunis* und *M. tropicus*, bei denen am M_3 5 Joche und ein Talon vorhanden sind. Die Stammesentwicklung drängt zu einer Jochvermehrung, wie wir das noch genauer sehen werden. Die Länge unseres M_3 mag im Maximum 155 mm betragen haben, also ebenso lang gewesen sein wie bei *M. oligobunis* var. *Felicis* (No. 20). Fast die gleiche Länge hat *M. Shepardi* Leidy von Contra Costa Co. Bei jungdiluvialen Rassen des *M. oligobunis* betrug die Länge etwa 175 mm. Die Breite des Zahns von Atotonilco misst am dritten Joch etwa 68 mm."

TYPE OF CORDILLERION OLIGOBUNIS ANTIQUISSIMUS

Fig. 515. Type right M_3, with one and a half crests broken off, of *Mastodon oligobunis* var. *antiquissima* Freudenberg, 1922 (Mus. Inst. Nac. Geol. Mex. v-187). From Valley of Amajaque, Hidalgo, Mexico. Reproduced from original photographs, courtesy of Doctor Freudenberg; upper figure one-fourth natural size, lower figure one-half natural size. Compare type figure Freudenberg, 1922, Taf. IX, figs. 3, 3a.

Osborn, 1926: Freudenberg reviews (*op. cit.*, pp. 113–118) the previous descriptions of *M. shepardi* Leidy, *M. oligobunis* Cope, *M. andium* Cuv., *D. tropicus* Cope, *M. præcursor* Cope, and concludes (p. 118): "Im folgenden unterscheide ich 4 verschiedene Mutationen oder Varietäten des *Mastodon* (*Dibelodon*) *oligobunis* Cope. Das sind: var. *antiquissima*, var. *Felicis*, var. *intermedia* und var. *progressa*. Vielleicht ist var. *antiquissima* identisch mit der verloren gegangenen Mandibel von Tlaxcala am Ostrande der Mesa central von Mexiko. Der Fundort Tlaxcala wird von Aguilera der Pliocänformation zugerechnet. Es sind blätterführende Tone mit Resten altertümlicher Säugetiere."

Osborn, 1931: The type figure of this subspecies does not show the crown view; consequently it is somewhat uncertain whether the *proportions* of this inferior molar are those of *Cordillerion* or of *Rhynchotherium*.

Cordillerion (?) **oligobunis felicis** Freudenberg, 1922

Figures 516 and 517

Pliocene. Puebla, Mexico.

The imperfect left superior grinding tooth, l.M^3, from Puebla, Mexico, constituting the type of this subspecies,[1] is doubtfully related to the genus *Cordillerion*, as implied by Freudenberg in his comparison of this type as related to, but specifically distinct from, the type of *Dibelodon tropicus* Cope; it resembles in its proportions *Cordillerion* rather than *Rhynchotherium*. The type was first figured by Felix (1891, Taf. XXX, fig. 1) as "*Mastodon Shepardi*"; it was subsequently photographed and refigured by Freudenberg (1922, Taf. X, figs. 1, 1a); with its single trefoils and four and a half ridge-crests, it agrees with the third superior molars of *Cordillerion andium* of Tarija (Fig. 488, also Fig. 504, 7), although it is more primitive than the *C. andium* molars in the lesser development of the tetartoloph and of the talon representing the pentaloph.

Mastodon oligobunis var. *Felicis*, Freudenberg, 1922. "Die Säugetierfauna des Pliocäns und Postpliocäns von Mexiko. II. Teil: Mastodonten und Elefanten." Geol. und Palaeont. Abhand., N.F., Band XIV (Band XVIII), Heft 3, pp. 120–123, "Taf. X, Fig. 1 u. 1a. Taf. XI, Fig. 2 u. 2a. Taf. XIII, Fig. 2. Text fig. 7." TYPE.—Left third superior molar, l.M^3. Original in Palæontological Museum of University of Leipzig. HORIZON AND LOCALITY.—Puebla, Mexico. TYPE FIGURE.—Freudenberg, *op. cit.*, Taf. X, figs. 1, 1a: "*Mastodon* (*?Dibelodon*) *oligobunis* var. *Felicis* nov. subsp. von der Aussenseite gesehen. ⅔ nat. Gr. Fig. 1a. Die Zahnkrone, von der Kaufläche gesehen. ⅔ nat. Gr. Original zu Felix (Beiträge etc. Bd. 3. t. 30. f. 1) aus der Gegend von Puebla, jetzt im Paläontologischen Museum der Universität Leipzig. Bezeichnend für die Art sind die kantigen Pyramiden der Haupthügel."

TYPE DESCRIPTION.—(Freudenberg, *op. cit.*, p. 120): "Der Typus dieser Art ist der von Felix [Footnote: Beiträge zur Geologie und Paläontologie der Republik Mexiko. 3. Paläontogr. 1891. pag. 132. t. 30 f. 1.'] abgebildete dritte obere Molar der

[1](1935) The type of this species may be compared with *Serbelodon*(?) *præcursor* (Fig. 397, p. 431 above) from the Blanco, Texas.

linken Seite, den er nach Copes Vorgang als *M. Shepardi* Leidy bezeichnet hat. Cope [Description of a lower jaw of *Tetrabelodon Shepardi*. Amer. Nat., 1889, Vol. XXIII, pp. 203, 204] beruft sich später auf diese Abbildung und auf seine vorausgegangene Beschreibung des *Dibelodon Shepardi* aus Mexiko. [Footnote: 'E. D. Cope, The extinct Mammalia of the valley of Mexiko. Loc. cit. 1884. pag. 5–7.']. Die Gründe, die auch hier gegen *M. Shepardi* sprechen, haben wir oben dargelegt. Jedenfalls gehören die mexikanischen Quartärformen alle zum Subgenus *Mastodon*, da nur obere Stosszähne vorhanden und diese ohne Schmelzbänder

TYPE SUPERIOR MOLAR OF CORDILLERION(?)[1] OLIGOBUNIS FELICIS

Fig. 516. Type left M^3 of *Mastodon oligobunis* var. *Felicis* Freudenberg, 1922. After Freudenberg, 1922, Taf. x, figs. 1, 1a, one-half natural size. From the locality of Puebla, Mexico; now in the Palæontological Museum of the University of Leipzig. The same tooth in a less fractured condition appears to be figured by Felix (1891, Taf. xxx, fig. 1) under the reference "*Mastodon Shepardi* Leidy."

Observe: (1) The four and a quarter crests, each crest bilobed; (2) trefoils on external lobes; (3) the convex profile of crown.

sind. Unsere Textfig. 4 stellt einen Unterkiefer derselben Unterart vor. Dieselbe wurde von Villada (l. c.) auf seiner t. 7 dargestellt. Das Original befindet sich im Museo Nacional in Mexiko. Hinter der kurzen und abwärts gebogenen Symphyse waren M_2 und M_3 gleichzeitig in Funktion. . . . Was mich bestimmt, diesen Zahn zu *M. oligobunis* var. *Felicis* zu stellen, das ist unter anderem seine geringe Grösse und die Schmalheit des Hinterendes, das bei *M. tropicus* besonders breit ist. Die Kulissenstellung der Halbjoche ist auch dort vorhanden (Taf. III [XI], Fig. 1), wennschon in anderer Weise entwickelt. Dort legen sich nämlich die Halbjoche in stumpfem Winkel aneinander, während bei *M. oligobunis* var. *Felicis* die beiden halben Querjoche sehr schief zur Zahnachse liegen, aber in einer Linie sich jeweils aneinander legen."

Fig. 517. Third left inferior molar, $l.M_3$, referred by Freudenberg to *Mastodon oligobunis* var. *Felicis*. Mus. Inst. Nac. Geol. Mex. 185a (20). From "Tlatlaya. Dto. Quetepec. Estado de Mexico." After original photograph, courtesy of Doctor Freudenberg, one-half natural size. Compare Freudenberg, 1922, Taf. XI, figs. 2, 2a. [= *Cordillerion*(?) *oligobunis felicis* of the present Memoir.]

Osborn, 1924: Comparing the ridge-crest formula, Cope's type of *Dibelodon tropicus* contains five and a quarter crests in M_3; Hay's type of *Gomphotherium gratum* contains four and a quarter crests in M^3; Freudenberg is certainly correct in regarding as an M^3 this type molar of *Mastodon oligobunis* var. *felicis* (Fig. 516).

Cordillerion(?) oligobunis intermedius Freudenberg, 1922

Figure 518

Pliocene or Pleistocene. Mexico, exact locality not recorded.

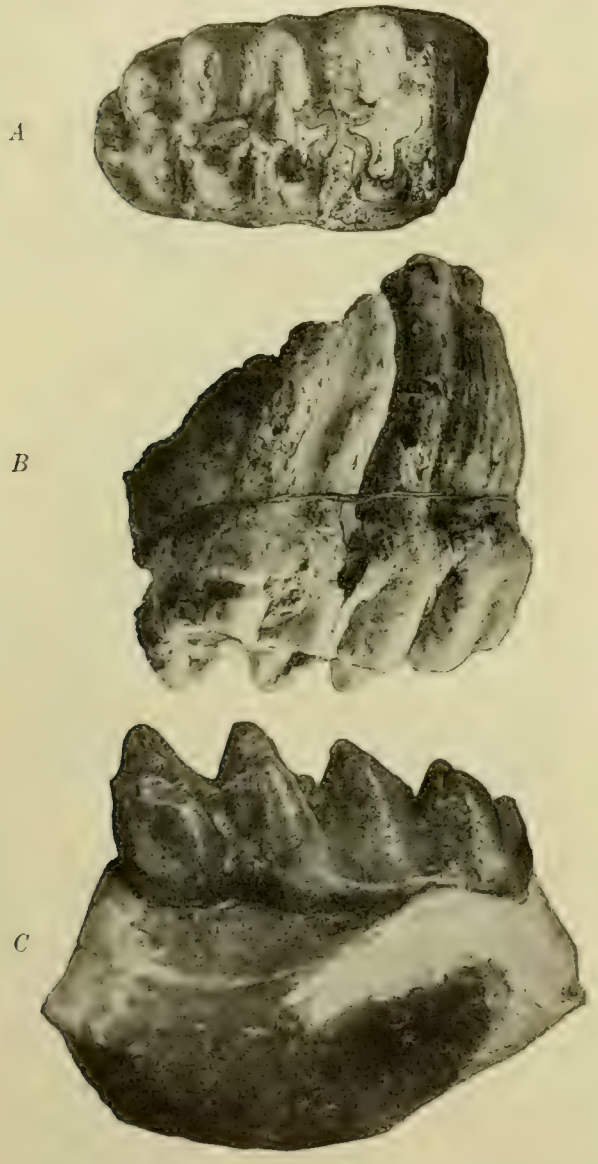
Freudenberg shows that this type in all its dimensions exceeds his type of *M. oligobunis* var. *Felicis*; he compares it with the type of *Dibelodon tropicus* Cope.

(Osborn, 1934) The type of this subspecies does not resemble the elongate five crested third superior molar of *Cordillerion* or that of *Rhynchotherium;* it is comparable rather to the short and broad third superior molar of *Trobelodon taoensis*, or possibly to the genus *Serbelodon* (Fig. 408).

Mastodon oligobunis var. *intermedia* Freudenberg, 1922. "Die Säugetierfauna des Pliocäns und Postpliocäns von Mexiko. II. Teil: Mastodonten und Elefanten." Geol. und Palaeont. Abhand.,

[1] With trefoils springing from the entoconelets and with reduced mesoconelets this molar resembles the type of *Serbelodon*(?) *praecursor* Cope (Fig. 397). See figure 517 opposite for crown view of $l.M_3$.

N.F., Band XIV (Band XVIII), Heft 3, pp. 123–126. TYPE.—A third right superior molar, r.M³. Mus. Inst. Nac. Geol. Mex. v–183 (155). HORIZON AND LOCALITY.—Locality not recorded. TYPE FIGURE.—*Op. cit.*, Taf. XII, figs. 1 and 2. Fig. 1: "*Mastodon oligobunis* var. *intermedia* Freudenb. subsp. nov. (No. 155), von der Innenseite gesehen. Ca. ⅓ nat. Gr. M³ r." Fig. 2. . . . "von oben gesehen, in nat. Gr."



TYPE (A, B) SUPERIOR MOLAR OF CORDILLERION(?) OLIGOBUNIS INTERMEDIUS. REFERRED MOLAR (C).

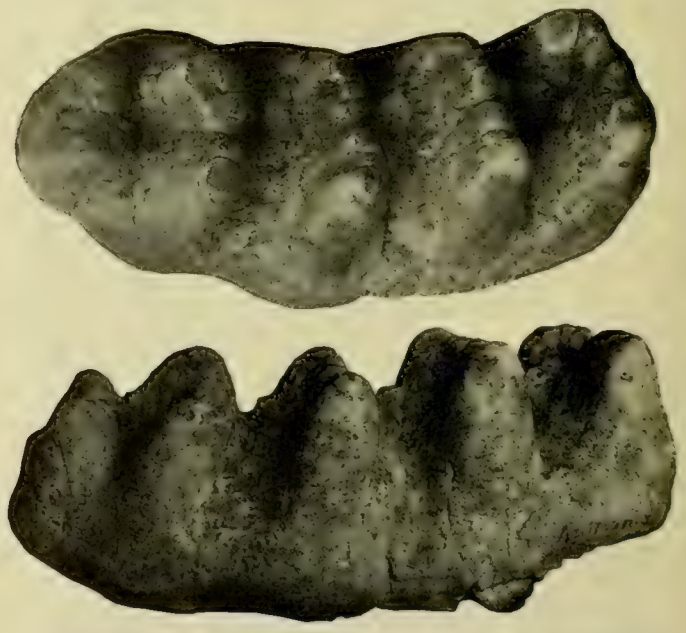
Fig. 518. Type third right superior molar, r.M³, of *Mastodon oligobunis* var. *intermedia* Freudenberg, 1922. Compare Freudenberg, 1922, Taf. XII, figs. 1 and 2. Mus. Inst. Nac. Geol. Mex. v-183 (155). All figures one-third natural size. Locality not recorded.

A, Crown view of type.

B, External view of same type, from photograph given to the present author.

C, Internal view of referred specimen (No. 157), after photograph. From Valley of Mexico.

TYPE DESCRIPTION.—(Freudenberg, *op. cit.*, p. 123): "Das Typusexemplar dieser Unterart ist ein oberer rechter M³ ohne Fundortangabe, aber jedenfalls aus Mexiko stammend, wie alle Säugetierreste im Museum des Instituto geologico zu Mexiko. Die Erhaltung ist die bei jungdiluvialen Resten übliche. Der Schmelz ist rein weiss, ebenso die stark hygroskopische Knochensubstanz. Sie gleicht am meisten den sog. Kalktuff-Fossilien, die nach Felix und Lenk im Staate Puebla vorkommen und Säugetiere einschliessen, etwa wie die Kalktuffe von Weimar und Taubach, denen sie sogar im Alter zu entsprechen scheinen. Der Originalzahn (M³) ist als Fig. 1 und 2 auf Taf. IV [XII] von der Seite und von oben abgebildet. No. 155 gibt sich durch seine grosse Breite und relative Kürze bei 4 Jochen und Talon sofort als M³ zu erkennen. Krone wie Wurzeln sind recht vollständig erhalten."



TYPE INFERIOR MOLAR OF CORDILLERION OLIGOBUNIS PROGRESSUS

Fig. 519. Type third left inferior molar, l.M₃, of *Mastodon oligobunis* var. *progressa* Freudenberg, 1922, one-half natural size. After photographs furnished by Doctor Freudenberg. Compare original type figures, Freudenberg, 1922, Taf. XIV, figs. 1 (lower) and 2 (upper) natural size. "Stammt von der Cannada (Schlucht) de Aculcingo" (Mus. Inst. Nac. Geol. Mex. 184a).

Cordillerion oligobunis progressus Freudenberg, 1922

Figure 519

Pliocene or Pleistocene. Cannada de Aculcingo, Mexico.

The comparison which Freudenberg makes with other specimens (1922, pp. 127, 128) indicates that this subspecies is more closely related to the type of *Cordillerion tropicus* Cope, although much more primitive.

The long, narrow type inferior molar of this subspecies certainly resembles in its proportions *Cordillerion* rather than *Rhynchotherium*. This type, a third left inferior molar tooth, l.M₃, from the canyon of Aculcingo, Mexico, is characteristic of *Cordillerion* in the development of its cones and trefoils; the trefoils are apparently of diminutive size; this tooth also presents a marked outward curvature.

M. [*Mastodon*] *oligobunis* var. *progressa* Freudenberg, 1922. "Die Säugetierfauna des Pliocäns und Postpliocäns von Mexiko.

II. Teil: Mastodonten und Elefanten." Geol. und Palaeont. Abhand., N.F., Band XIV (Band XVIII), Heft 3, pp. 126, 127. TYPE.—A third left inferior molar, l.M_3. Mus. Inst. Nac. Geol. Mex. 184a. HORIZON AND LOCALITY.—"Stammt von der Cannada (Schlucht) de Aculcingo," Mexico. TYPE FIGURE.—Freudenberg, *op. cit.*, Taf. XIV, Figs. 1 and 2: "*Mastodon oligobunis* var. *progressa* Freudenb. subsp. nov. M_3 des linken Unterkiefers in nat. Gr. Stammt von der Cannada (Schlucht) de Aculcingo. (No. 17) der Leihliste. Auch der rechte Zahn ist vorhanden. Hügel ohne Kanten. Fig. 1 von Innen gesehen. Fig. 2 von der Kaufläche gesehen."

TYPE DESCRIPTION.—(Freudenberg, *op. cit.*, p. 127): "No. 17 der Leihliste ist letzter unterer Molar der linken Seite (M_3 l.) mit merkwürdiger Biegung nach innen, wie sie an M^3 von *Elephas* nicht selten beobachtet wird. Durch diese nach aussen leicht konkave Biegung, verbunden mit einer radialen Anordnung der Querjoche, wird man an *Elephas* erinnert. Auch sind die äusseren und inneren Halbjoche nicht gegeneinander verschoben, noch sind deutliche Sperrhügel vorhanden. Diese befinden sich offenbar in Rückbildung. Der Zahn erinnert von allen am meisten an *Stegodon*. Es ist eine fünfjochige Form mit einem kleinen Talon. Wir haben sie zu *M. oligobunis* gestellt, da wir Schritt für Schritt ihren Stammbaum verfolgen konnten. Die hintere Jochpartie scheint in etwas Zement eingehüllt zu sein. Vorn hat die Abkauung noch kaum begonnen. Die Berührungsfläche der Jochspitzen läuft der Zahnbasis annähernd parallel, ist also sehr verschieden von M_3 des *M. oligobunis* var. *Felicis*. Das gleiche würde man von der Usurfläche sagen können, wenn diese besser entwickelt wäre. Fundort ist laut Aufschrift die Cannada de Aculcingo."

Freudenberg concludes that *M. antiquissima*, *M. intermedia*, and *M. progressa* constitute a series of ascending mutations which he terms *varieties* (*op. cit.*, p. 137): "In der Formenreihe des *M. oligobunis* Cope aus Mexiko glaube ich einen Fall von Stammesentwicklung beschrieben zu haben, wo Jochvermehrung und eine bald mehr bunodonte, bald stärker lophodonte Gestaltung der Schlmelzhügel zu feststehenden Mutationen geführt hat. Da man aber den Züchtungsversuch und die Analyse der Nachkommenschaft nicht mehr vornehmen kann, so habe ich mich dafür entschieden, die unterscheidbaren Formen als Variationen bei der Namengebung einzuführen."

THE RARE NOTOROSTRINES OF TEXAS AND SOUTHERN CALIFORNIA

The first Notorostrine described from the United States was the *Gomphotherium gratum* of Hay, 1917, from Texas, and the second was the *Dibelodon edensis* of Osborn, 1922, from southern California. The most recently described species are *Anancus orarius* Hay, 1926, and *A. defloccatus* Hay, 1926, from near Sinton, Texas, and *Anancus bensonensis* Gidley, 1926, from near Benson, Arizona. The present writer includes all of these species in the genus *Cordillerion*. Consequently the five North American species known at present are:

1917 *Cordillerion gratum* Hay, Pittbridge, Burleson Co., Texas, with 4¼ ridge-crests in M^3, hence progressive.

1922 *Cordillerion edensis* Osborn, Eden formation southern California, ridge-crests of M^3 at present unknown.

1926 *Cordillarion orarius* Hay, near Sinton, San Patricio Co., Texas, with 5+ ridge-crests in M^3, hence progressive.

1926 *Cordillerion defloccatus* Hay, near Sinton, San Patricio Co., Texas, with 5+ ridge-crests in M_3, hence progressive.

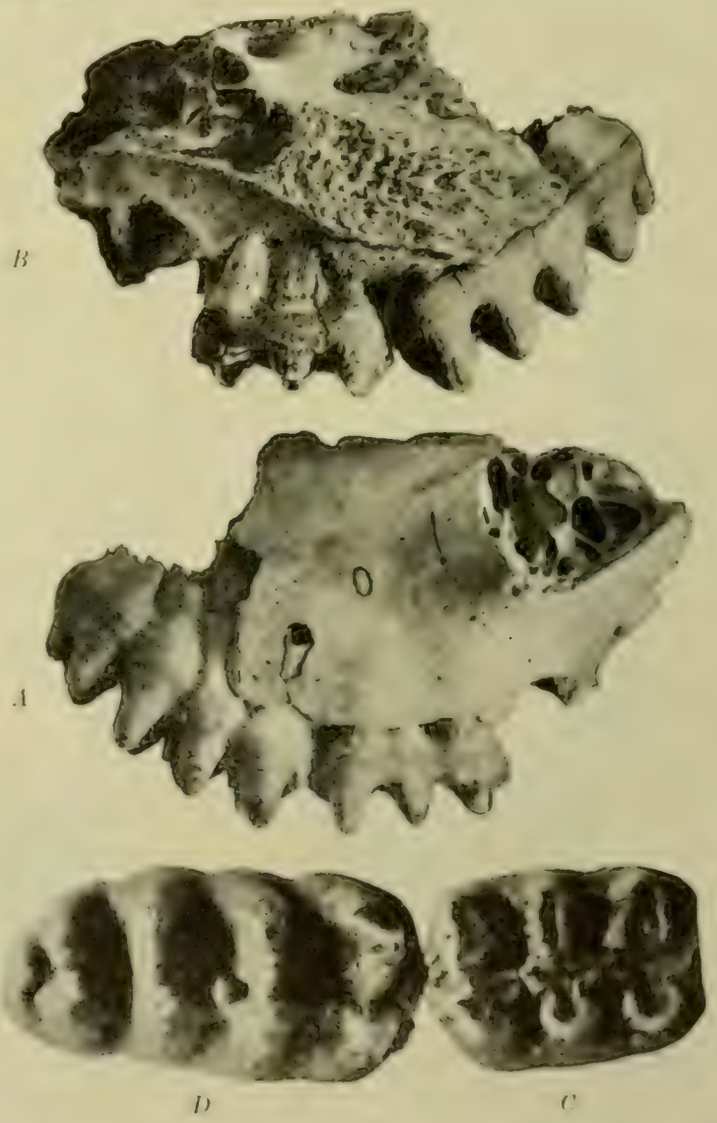
1926 *Cordillerion bensonensis* Gidley, near Benson, Cochise Co., Arizona, with 4+ ridge-crests in M^3, hence primitive.

Cordillerion gratum Hay, 1917

Figure 520

Pliocene. Pittbridge, Burleson County, Texas, on the Brazos River.

The type superior teeth of *Cordillerion gratum* (Fig. 520) are somewhat more primitive than the corresponding teeth of *C. andium* of Tarija, Bolivia, as figured by Gervais, 1855, Pl. v, fig. 3 (Fig. 488).



TYPE SUPERIOR MOLARS OF CORDILLERION GRATUM

Fig. 520. Type r.M^2-M^3 of *Gomphotherium gratum* Hay, 1917.1, Pl. III, figs. 3 and 4 (C, D), Pl. IV, figs. 1 and 2 (A, B). A.—External view of maxilla B.—Internal view of same. One-fourth natural size. C. Crown view of M^2. D.—Crown view of M^3. One-third natural size. From Pittbridge, Burleson County, Texas, on the Brazos River.

Hay erroneously referred his excellent type specimen (Fig. 520) to the genus *Gomphotherium* [=*Trilophodon*], but the crown and side views of the second and third superior grinding teeth are seen to be closely similar to those of *Cordillerion andium*.

Gomphotherium gratum Hay, 1917. "Descriptions of Some Fossil Vertebrates Found in Texas." Bull. Univ. of Texas, No. 71, December 20, 1916 (not actually published until 1917), pp. 18–21. Type.—"A portion of a right maxilla containing the second and third molars; also the third molar of the left side of the same individual. The property of Dr. Mark Francis, College Station, Texas." Horizon and Locality.—Pittbridge, Burleson County, Texas, on the Brazos River. Pliocene. Type Figure.—Hay, *op. cit.*, 1916 [1917.1], Pl. III, figs. 3 and 4, and Pl. IV, figs. 1 and 2.

Type Description.—(Hay, *op. cit.*, pp. 18 and 19).— . . . "Second upper molar with three cross-crests, third upper molar with four. Inner halves of the crests furnished with anterior and posterior buttresses and, on being worn down, presenting trefoils. . . .

Measurements of teeth in millimeters.

Dimensions taken	M^2	M^3
Length of tooth at the base	113	178
Width at the first crest	77	87
Width at second crest	83	87
Width at third crest	81	83
Width at fourth crest		73
[Breadth-length index	73	49]

Besides the four cross-crests of the third molar there is a talon consisting of two large coalescent tubercles. An observation of the grinding face of the second molar (pl. III, fig. 3) shows that there is produced on wear a distinct trefoil on the inner half of each crest. The lobes of these which are produced by the front and rear buttresses of each crest come into contact at the middle of the width of the tooth and block up the transverse valley."

Osborn, 1933: This type adds welcome confirmation of the presence of the genus *Cordillerion* in the southwestern United States.

Cordillerion edensis Osborn, 1922

Figures 471, 498, 500, 522, 523

Eden formation, Mt. Eden Hot Springs, San Bernardino County, southern California. Upper Pliocene, but somewhat more ancient geologically than the Blanco (*fide* Frick, 1921).

The type of *Cordillerion edensis* is the incomplete rostrum and superb pair of incisive tusks represented in figure 523 (A_1, superior aspect, A_2, palatal aspect), in comparison with (B) the typical *Cordillerion andium* of Tarija, Bolivia, shown in palatal aspect to the same scale. On close examination it will be observed that while the tusks with their enamel bands are similar, they are by no means identical; in other words, while there is no question as to generic relationship, the tusks of *C. edensis* represent a more primitive stage of evolution; they are stouter, more simply incurved, less completely spiral, the enamel band is relatively broader and does not make the complete spiral twist from the outer to the inner side, as observed in the more highly specialized *C. andium* of Tarija. For this important specific stage we are indebted to Mr. Childs Frick in his prolonged and highly successful explorations and researches in our western Pliocene and especially in the very difficult exploration of the Eden formation of San Bernardino County, southern California, carried on under his direction since 1916 by Mr. Joseph Rak. The author is also indebted to Mr. Frick for the opportunity of first describing and figuring these type tusks as *Dibelodon edensis* in the year 1922 (Osborn, 1922.564, p. 3, fig. 1).

History.—Unfortunately the present author's original description (Osborn, 1922.564) of these type tusks of *Cordillerion edensis* was marred by the erroneous association both by Frick (1921, 1926) and Osborn (1922) of these *Cordillerion* tusks with the type grinding teeth (Fig. 470) of "*Trilophodon* (*Tetrabelodon*) *shepardi edensis*" Frick, 1921, p. 405, a species now transferred to *Rhynchotherium shepardi edense* (see p. 496 of the present Memoir). This erroneous association is fully explained in Chapter XI, pages 496–501 above. These tusks, first described by Osborn in 1922 as *Dibelodon edensis* (Frick), are now transferred to *Cordillerion edensis*.

Type.—Univ. Calif. 24047. Frick's original description of this type is as follows (1921, pp. 405, 408): "portions of premaxilla and tusks, Univ. Calif. Coll. Vert. Pal. no. 24047 (pl. 50), all from Univ. Calif. loc. 3269. . . . A fragment of a premaxilla containing portions of two tusks [Footnote: 'At the time of going to print the basal portions of the tusks have alone been recovered, the upper

Fig. 521. Map showing the position of the San Timoteo and Eden deposits in geographic relation to the Etchegoin, Ricardo, Chanac, Pinole Tuff-Orinda, Thousand Creek, Rattlesnake, Snake Creek, Republican River Pliocene. These are the more important of the Pliocene fossil mammal deposits lying west of the Mississippi River. After Frick, 1921, p. 280, fig. 1a.

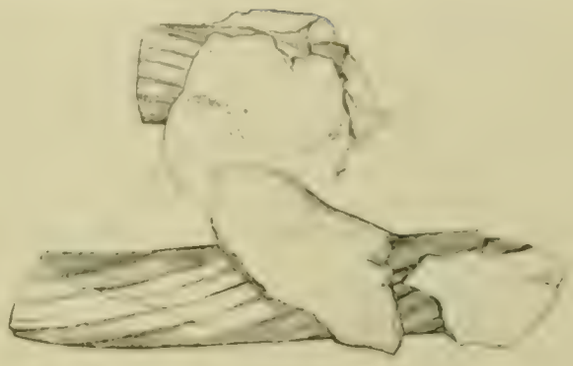
7. San Timoteo and Eden horizon of California.
6. Ricardo horizon of California.
5. Chanac horizon of California.
4. Etchegoin horizon of California.
3. Pinole Tuff-Orinda horizon of California.
2. Thousand Creek horizon of Nevada.
1. Rattlesnake horizon of Oregon.
11. Blanco horizon of Texas.
10. Republican River horizon of northern Kansas.
9. Loup River of central Nebraska.
8. Snake Creek of western Nebraska.

Several horizons west of the Mississippi.

surface of the adjacent portions lying exposed in the quarry for eighteen inches, and the total length of the tusks being estimated at four feet.'] is represented in plate 50. The specimens are of oval section, being composed of a central core surrounded by four concentric rings. The surface where unbroken is highly polished; a broad band of enamel is present on each; the inner texture is striated in the direction of the tusk curvature, which is distinctly inward and outward."

OSBORN'S ORIGINAL DESCRIPTION (1922) OF DIBELODON EDENSIS

Osborn, 1922.—At the special request of Mr. Childs Frick, Osborn (1922.564, pp. 1, 2) described the above-mentioned additional material as follows: "During the years 1916–1917, Mr. Childs Frick (1921, p. 279) . . . conducted field work in southern California as part of Professor John C. Merriam's comprehensive plan for the study of the geologic and faunal history of the Pacific coast. In the rich 'Eden beds' were discovered proboscidean remains which the author (*op. cit.*, p. 405) determined as follows:



Type Tusks of Cordillerion edensis

Fig. 522. Bases of right and left superior tusks and portions of premaxillaries originally (Frick, 1921, Pl. L—this figure) part of the type of *Trilophodon* (*Tetrabelodon*) *shepardi edensis*. The distal portions of these tusks and additional pieces of the premaxillaries were subsequently recovered, from which the type restoration of *Dibelodon edensis* (Fig. 523) was made. These type tusks are now transferred to *Cordillerion edensis* (cf. Fig. 471).

Restored Type Rostrum and Superior Tusks (Univ. Calif. 24047) of Cordillerion edensis Osborn (A_1, A_2), compared with those of C. andium (B)

Fig. 523. Comparison of *Cordillerion edensis* of California (A_1, A_2) and *Cordillerion andium* of Bolivia (B). All figures reduced to approximately one-tenth natural size. After Osborn, 1922.564, p. 3, fig. 1.

A_1, Superior view of the rostrum and incisive tusks of the type *Dibelodon* [=*Cordillerion*] *edensis* Osborn; this is probably a male individual. These tusks belong to the Geological Museum of the University of California (Univ. Calif. 24047).

A_2, Palatal view of the same type showing the remarkable similarity of detail to the palate of *Cordillerion andium*.

B, Palatal view of *Cordillerion andium* of Tarija, Bolivia, described and figured by Nordenskiöld (1903, Taf. I, fig. 2); probably a male individual, owing to the large size of the tusks.

Trilophodon (Tetrabelodon) shepardi edensis, n. subsp.

"'*Type specimen.*—The portion of a skull and posterior maxillaries, containing the last molar of the left side and a section of that of the right side, Univ. Calif. Coll. Vert. Pal. no. 23501 (fig. 160); two associated molars from the left and the right side respectively, Univ. Calif. Coll. Vert. Pal. 23503, 23504 (figs. 164, 162); and portions of premaxilla and tusks, Univ. Calif. Coll. Vert. Pal. no. 24047 (pl. 50), all from Univ. Calif. loc. 3269.'"

"The Eden beds are correlated with the Snake Creek of Nebraska, the Rattlesnake of Oregon, the Thousand Creek of Nevada, and the Middle Etchegoin of California, namely, of Middle Pliocene age. Excavation in the Eden beds continued by Mr. Frick resulted in the recovery of the complete upper tusks of one of the cotype specimens which were figured by the author (*op. cit.*, Pl. 50): 'Figs 1 and 2. Portions of premaxillary and tusks of Eden type specimen, no. 24047, ×¼.' Under Mr. Frick's direction these cotype tusks have been carefully restored and mounted, as represented in the present article (Fig. 1). Mr. Frick has kindly offered this precious cotype to the present writer for redescription together with newly discovered grinding teeth found in the same ledge of the Eden beds, representing several individuals which probably belong to the same species. This new cotype and the associated material prove that the Eden proboscidean is very close indeed in all its characters to the classic *Mastodon andium* Cuvier of the valley of Tarija, Bolivia, and especially to the skull described by Nordenskiöld . . . in 1903."

"The matter of chief interest and importance is that these notorostrine proboscideans migrated along the western coast of North America EN ROUTE to their habitat in the Andes. The generic name to be applied to this animal is not *Trilophodon* Falconer but *Dibelodon* Cope. Cope (1884) . . . founded *Dibelodon* on three species, namely, *Dibelodon* (*Mastodon*) *shepardi* Leidy, *Dibelodon tropicus* Cope, and *Mastodon humboldtii* Cuvier, the first being specified as type. Consequently, *Trilophodon* (*Tetrabelodon*) *shepardi edensis* Frick = *Dibelodon edensis* (Frick)."

"CHARACTERS.—As shown in Fig. 1, A_1, A_2, *B*, the premaxillæ, the anterior portion of the palate, the dentition, and the enamel areas of the tusks are so similar to those of the Tarija skull referred to *M. andium* by Nordenskiöld, that if the Eden cotype had been found at Tarija it would without question have been referred to the species *Dibelodon andium*. The enamel ribbon in both the Eden and the Tarija specimens leaves the skull on the OUTER border of the tusk which by an inward rotation on its own axis carries the enamel (*e e e*) to the INNER border; in both photographic figures the enamel borders are artificially indicated with a faint white line. The *Dibelodon edensis* cotype is a male individual, consequently the tusks are more robust; it is a younger individual, hence the tusks are relatively shorter and the twisting of the enamel band does not extend quite so far. It appears probable that *Dibelodon edensis* is less progressive than *Dibelodon andium* in its tusk formation."

COMPARISON WITH CORDILLERION ANDIUM

The dissociation of these type *Cordillerion* tusks from the *Rhynchotherium shepardi edense* grinding teeth necessitates a specific distinction of *Cordillerion edensis* of Eden from *C. andium* of Tarija. Comparison is made (Fig. 523) with the superb specimen in the Stockholm Museum, described and figured by Erland Nordenskiöld in 1903, in his Memoir "Über die Säugetierfossilien des Tarijatals, Südamerika. I. *Mastodon Andium* Cuv.," Kungl. Svenska Vetensk.-Akad. Handl., Band 37, No. 4, pp. 1–30, Taf. I–VI. The Tarija tusks, of an exposed length of 960 mm., total length including part within alveolus 1290 mm., transverse diameter 102 mm., exhibit a broader enamel band (61 mm.), artificially indicated in figure 523 by a faint white line. The enamel ribbon both in the Eden and Tarija specimens leaves the skull on the outer border of the tusk which by an inward rotation on its own axis carries the enamel to the inner border. Both specimens are probably males. In the *C. edensis* type the tusks are much more robust, they are relatively shorter, and the twisting of the enamel band does not extend quite so far; consequently *C. edensis* is much less progressive than *C. andium* in the formation of its superior incisive tusks.

Cordillerion edensis differs from the Notorostrines hitherto described in being based on the superior tusks only, whereas previously described species of the United States are based on the grinding teeth, under different nomenclature, namely, *Gomphotherium gratum* Hay, 1917, *Anancus orarius* Hay, 1926, *Anancus defloccatus* Hay, 1926, and *Anancus bensonensis* Gidley, 1926. Subsequent exploration may reveal specific as well as generic resemblances of these Upper(?) Pliocene stages of *Cordillerion*.

GEOLOGIC AGE.—As detailed in Chapter XI above in the description of *Rhynchotherium shepardi edense* (shown in the map, Fig. 472), *Cordillerion edensis* occurs in the Eden beds with the beaked mastodont *R. shepardi edense*, with the peccary *Prosthennops edensis*, with the camel *Pliauchenia merriami*, and with the primitive horse *Pliohippus* (*?*) *spectans*, an Eden fauna of Middle to Upper Pliocene age, less advanced than the Blanco which closes the Pliocene. Consequently *C. edensis* is more primitive and geologically more ancient than *C. andium*.

Cordillerion orarius Hay, 1926

Figure 524

Probably of Pliocene age. West bank of Aransas River, in San Patricio County, near the town of Sinton, Texas.

In the present Memoir the species *Gomphotherium gratum* Hay, 1917, has been transferred to the genus *Cordillerion;* consequently it follows that the species *Anancus orarius* Hay should also be transferred to the same genus and species, i.e., *Cordillerion orarius*, without further expression of opinion as to whether this species is distinct from one or all of the species of *Cordillerion* previously described from the United States and Mexico, namely, *Cordillerion gratum*, *C. edensis* (Texas and California), *C. tropicus*, *C. oligobunis*, *C. oligobunis antiquissimus*, *C.*(?) *oligobunis felicis*, *C.*(?) *oligobunis intermedius*, and *C. oligobunis progressus* (Mexico).

Anancus orarius Hay, 1926. "A Collection of Pleistocene Vertebrates from Southwestern Texas." Proc. U. S. Nat. Mus., Vol. LXVIII, Art. XXIV, pp. 8–14. TYPE.—(*Op. cit.*, 1926.3, pp. 8, 9): "The mastodon to which this name is applied is represented by the symphysis and somewhat less than one-half of both horizontal rami with a much-worn right second molar, the complete crown of the lower right third molar, the detached lower left third molar [Nat. Mus. 11,377], a detached upper left second molar—and

a section of the right maxilla supporting the third molar nearly complete, these parts belonging to one individual." HORIZON AND LOCALITY.—(*Op. cit.*, p. 1): "In August, 1925, Dr. Mark Francis, of College Station, Texas, sent the writer a small collection of fossil teeth and bones which he had collected near the west bank of Aransas River, in San Patricio County. The locality is described as being about 1 mile north of the bridge on which the St. Louis & Brownsville Railroad crosses the Aransas. It is also about 20 miles southwest of Refugio. Nearer is a town named Sinton, and for convenience the collection will be spoken of as from Sinton." Probably of Pliocene age. TYPE FIGURE.—(*Op. cit.*, 1926, p. 17): "Plate 2, Fig. 1. *Anancus orarius*. Type. Lower right third molar, showing grinding surface. ×⅔. . . . Plate 3, Fig. 1. *Anancus orarius*. Upper right third molar, showing grinding surface. Type. ×⅔. . . . Plate 4, Fig. 1. *Anancus orarius*. Part of maxilla with third molar. Seen from inner side and showing crown and roots of the tooth. Type. ×0.43. . . . Plate 5, Figs. 1–3. *Anancus orarius*. 1. Right maxilla with third molar. Seen from right side. Type. ×0.3±. 2. Lower face of symphysis showing keels, included furrow, foramina, and possible sockets for vestigial lower tusks. Lingual groove above. ×0.6± 3. Front of lower jaw with the second and third molars. Seen from right side. × 0.28±."

TYPE DESCRIPTION.—(Hay, 1926.3, p. 9): "The part of the lower jaw preserved is remarkably short and deep. From the front of the tooth row the profile turns downward more abruptly than is usual, even in *Mammut americanum* (pl. 5, fig. 3). The depth of the jaw at the front of the tooth row is 200 mm. The lower face of the symphysis forms an ascending curve measuring 150 mm. The hinder face rises perpendicularly a distance of 130 mm. to the lingual gutter. This gutter runs forward a little and then turns rapidly downward to meet the ascending curve of the lower face of the symphysis in the blunt beak. The length of the gutter is close to 190 mm. At its lower end it is only about 25 mm.

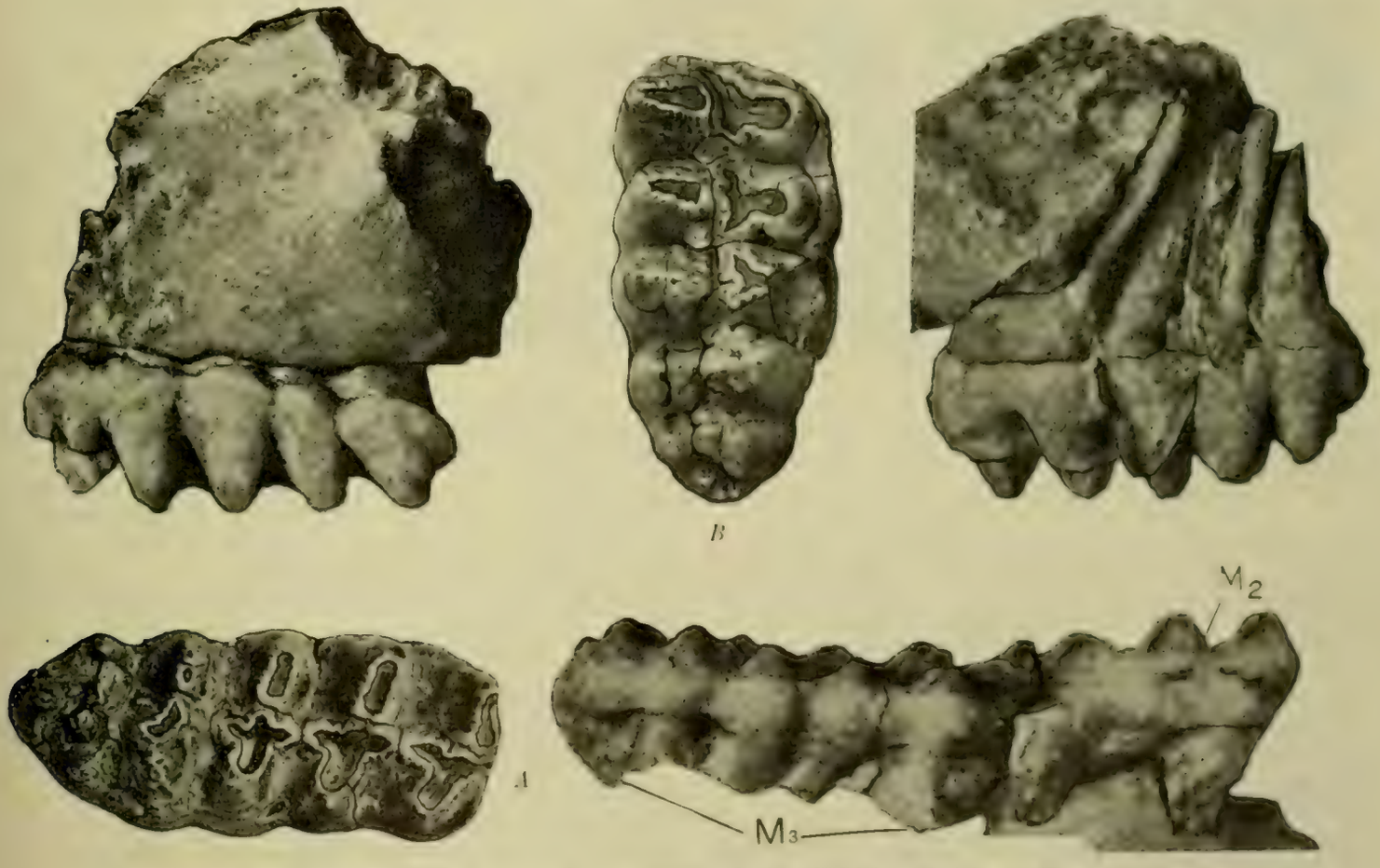


Fig. 524. TYPE SUPERIOR AND INFERIOR MOLARS OF CORDILLERION ORARIUS HAY

After Hay, 1926.3, Pls. II–V, Mark Francis Collection, 1925

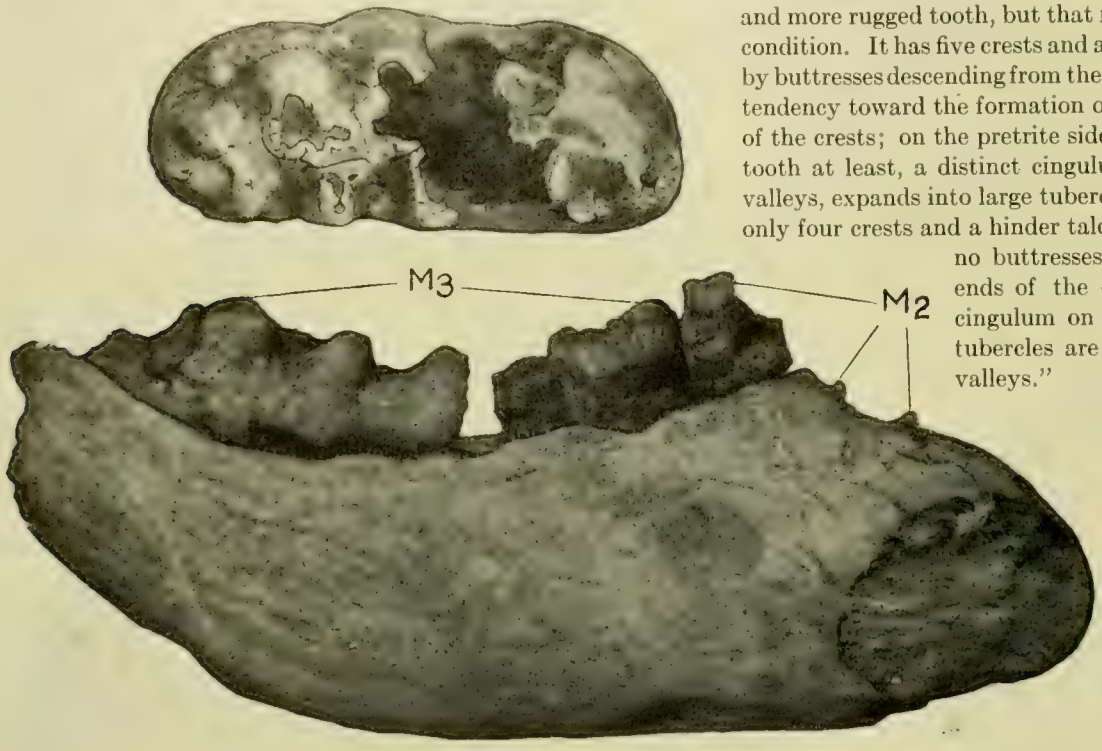
All figures about two-thirds natural size

A, Type third right inferior molar, r.M_3, crown view; also external view of second and third right inferior molars, r.M_2, r.M_3. After Hay, 1926, Pl. II, fig. 1, and Pl. V, fig. 3. Length of M_3 223 mm., breadth 95 mm., 5½ ridge-crests.

B, Three aspects of the third right superior molar, r.M^3. After Hay, 1926, Pl. V, fig. 1 (left), Pl. III, fig. 1 (center), Pl. IV, fig. 1 (right). Length of r.M^3 202 mm., breadth at second ridge-crest 105 mm., 5+ ridge-crests.

Observe in r.M_3 5½ ridge-crests, external trefoils complete in the anterior lophs, rudimentary in the tetartolophid, absent in the pentalophid; observe in r.M^3 5+ridge-crests; tetartoloph and pentaloph narrowing.

wide, and it is nowhere more than 45 mm. deep. The lower face of the symphysis is at first flat, but it soon presents two slightly diverging keels separated by a sharp furrow (pl. 5, fig. 2). In this are seen the openings of several foramina which probably transmitted nerves and blood vessels to the lower lip."



Type of Cordillerion defloccatus

Fig. 525.—Type of *Anancus defloccatus* Hay, 1926.3, Pl. VII, and Pl. VIII, fig. 1. One-half natural size.

Portion of left mandible showing third left inferior molar, l.M_3, also fragment of l.M_2. After Hay, *op. cit.*, Pl. VIII, fig. 1.

Crown view of third left inferior molar, l.M_3, with injured grinding surface. After Hay, *op. cit.*, Pl. VII.

"Where the keels and the ridges bounding the lingual gutter meet there is on each side a constricted foramen which opens directly backward into the jaw and has a long diameter of 10 mm. It seems possible that these foramina represent the sockets of vestigial lower tusks; but, as shown by the somewhat injured alveolar ridges bounding the lingual gutter, a canal, which probably transmitted a branch of the inferior dental nerve, opens into the supposed socket through its roof. Possibly the lower portion of the openings is all that remains of the sockets. On Figure 3 of Plate 5 no part of the lingual groove is seen. At the right hand in the lower half of the border a part broken away exposes the canal which transmitted the dental nerve. In Figure 2 on the left side (right in the specimen) the upper dark spot represents this canal 40 mm. higher up than that taken to be a possible socket. On the side of the jaw in front of the second molar are three openings for exit of branches of the nerve mentioned."

Comparison with the Species Anancus gratus and A. brazosius.—On pages 12 and 13 of Hay's communication he compares his type of *Anancus orarius* very closely with a tooth from Fort Worth, Texas, which he referred to *Anancus gratus* [*Gomphotherium gratum*]. He now transfers this referred specimen to the present species *A. orarius* and contrasts *A. orarius* with *A. gratus* (Hay, 1917.1, p. 18, Pls. III, IV) as follows (Hay, 1926.3, p. 13):

"The upper third molar of the type of *Anancus orarius* differs in various respects from that of *A. gratus* [Footnote: 'Hay, Bull. Univ. Texas, No. 71, 1917, p. 18, pls. 3, 4.']. *A. orarius* is a larger and more rugged tooth, but that might be due to sex or some other condition. It has five crests and a talon; the third valley is blocked by buttresses descending from the adjacent crests; there is a distinct tendency toward the formation of buttresses on the posttrite ends of the crests; on the pretrite side there is, on the front half of the tooth at least, a distinct cingulum, and this, at the ends of the valleys, expands into large tubercles. In *Anancus gratus* there are only four crests and a hinder talon; the third valley is wide open; no buttresses are developed on the posttrite ends of the crests; there are no traces of a cingulum on the sides of the tooth; and no tubercles are developed at the ends of the valleys."

Hay also compares the type of *Anancus orarius* with that of *A. brazosius*[1] (*op. cit.*, 1926.3, pp. 13 and 14) as follows:

"*Anancus orarius* differs in its lower hinder molar distinctly from that of *A. brazosius* [Footnote: 'Hay, Pan. Amer. Geologist, vol. 29, 1923, p. 112, pl. 8, figs 1, 2.']. The width is 0.45 of the length; the main cones are wedge shaped and the valleys are wide; the buttresses are simple and they do not block to a great height the valleys. In *Anancus brazosius* the width is only 0.40 of the length of the tooth; the main cones are high and columnar; the valleys are narrow; the buttresses are more complicated; and they block the valleys to a relatively great height."

Cordillerion defloccatus Hay, 1926

Figure 525

Probably of Pliocene age. West bank of Aransas River, in San Patricio County, near the town of Sinton, Texas.

From the following description and type figures of the species *Anancus defloccatus* Hay, it appears probable that these types should be transferred to the genus and species *Cordillerion defloccatus* without further expression of opinion as to the separability of this species from those previously described from the United States and Mexico, namely, *Cordillerion gratum, C. edensis* (Texas and California), *C. tropicus, C. oligobunis, C. oligobunis antiquissimus, C.* (?) *oligobunis felicis, C.* (?) *oligobunis intermedius,* and *C. oligobunis progressus* (Mexico).

Anancus defloccatus Hay, 1926. "A Collection of Pleistocene Vertebrates from Southwestern Texas." Proc. U. S. Nat. Mus., Vol. LXVIII, pp. 14–16 and 18. Type.—(*Op. cit.*, 1926.3, p. 14): "The second mastodon found near Sinton is represented by the

[1]Referred by Osborn in the present Memoir to *Trilophodon* (*?Tetralophodon*) *brazosius* (see p. 374 above).

left horizontal ramus and parts of its second and third molars, and by the hinder half of the lower right third molar [Nat. Mus. 11,378]. The individual was one of rather advanced age, as the hinder teeth are worn on all the crests." HORIZON AND LOCALITY.—Near west bank of Aransas River, San Patricio County, about twenty miles southwest of Refugio, but nearer to the town named Sinton, Texas, hence known as the Sinton collection; from same locality as the type of *Anancus orarius*. Probably of Pliocene age. TYPE FIGURE.—*Op. cit.*, Pl. VII, and Pl. VIII, fig.1: "Plate 7, Fig. 1. *Anancus defloccatus*. Lower left third molar, showing the injured grinding face. Type. ×⅔. Plate 8, fig. 1. *Anancus defloccatus*. Horizontal ramus showing its inner face, the symphysis, and the second and third molars. Type. ×0.3.±"

TYPE DESCRIPTION.—(Hay, 1926.3, p. 14): "Name from Latin *defloccaius*, a worn out, rusty old fellow (Ainsworth's Dictionary).

The horizontal ramus (pl. 8, fig. 1) is quite different from that of *Anancus orarius*, being much lower in front, 150 mm. or less at the front of the second molar, instead of 200 mm. as in *A. orarius*. Below this point the thickness is 105 mm. At the rear of the third molar the height is 130 mm., the width 180 mm. The symphyseal articulation is 135 mm. long and 96 mm. high. The jaw seems not to have ended in a beak as in many mastodons. There are three mental foramina, all opening near the alveolar border. A small one is situated below the hinder border of the front root of the second molar, another just below the front border, and a third about 35 mm. further forward. The second and the third have a diameter of about 5 mm."

Second molar, estimated width in front 70 mm., at the rear 100 mm.; only three crests.

Third molar, estimated length 230 mm., consisting of five crests and a hinder talon; width at protolophid 100 mm., at tritolophid 101 mm., at tetartolophid 93 mm., at pentalophid 85 mm.

COMPARISON.—(Hay, 1926.3, p. 15): "This lower third molar must be compared with that of *A.* [=*Cordillerion*] *orarius*. However much they differ, however closely they agree, the jaws testify that two species are present. It is evident that the molar of *A. defloccatus* had crests less elevated than those of *A.* [=*Cordillerion*] *orarius*. Also there is an evident tendency to the production of trefoils on the posttrite side of the crests. The presence of a distinct cingulum on the pretrite side of the crown and of the large, knoblike prominences at the ends of the valleys distinguish this species from *A. orarius*."

Cordillerion bensonensis Gidley, 1926

Figure 526

Upper Pliocene. Near Benson, Cochise County, Arizona, west side of the San Pedro Valley.

From the excellent illustration of this species it is quite evident that this type is far more closely related to *Cordillerion andium* than to either of the brevirostral genera *Anancus or Stegomastodon*. Consequently we may with confidence refer this type specimen (Nat. Mus. 10538) to the genus *Cordillerion;* it belongs with the more primitive division, in which the second superior molars are three crested and the third superior molars are four crested, with two supplementary posterior conelets representing the pentaloph. The portions of the rostrum are closely similar to those of *Cordillerion andium* and *C. edensis*, as shown in figure 523.

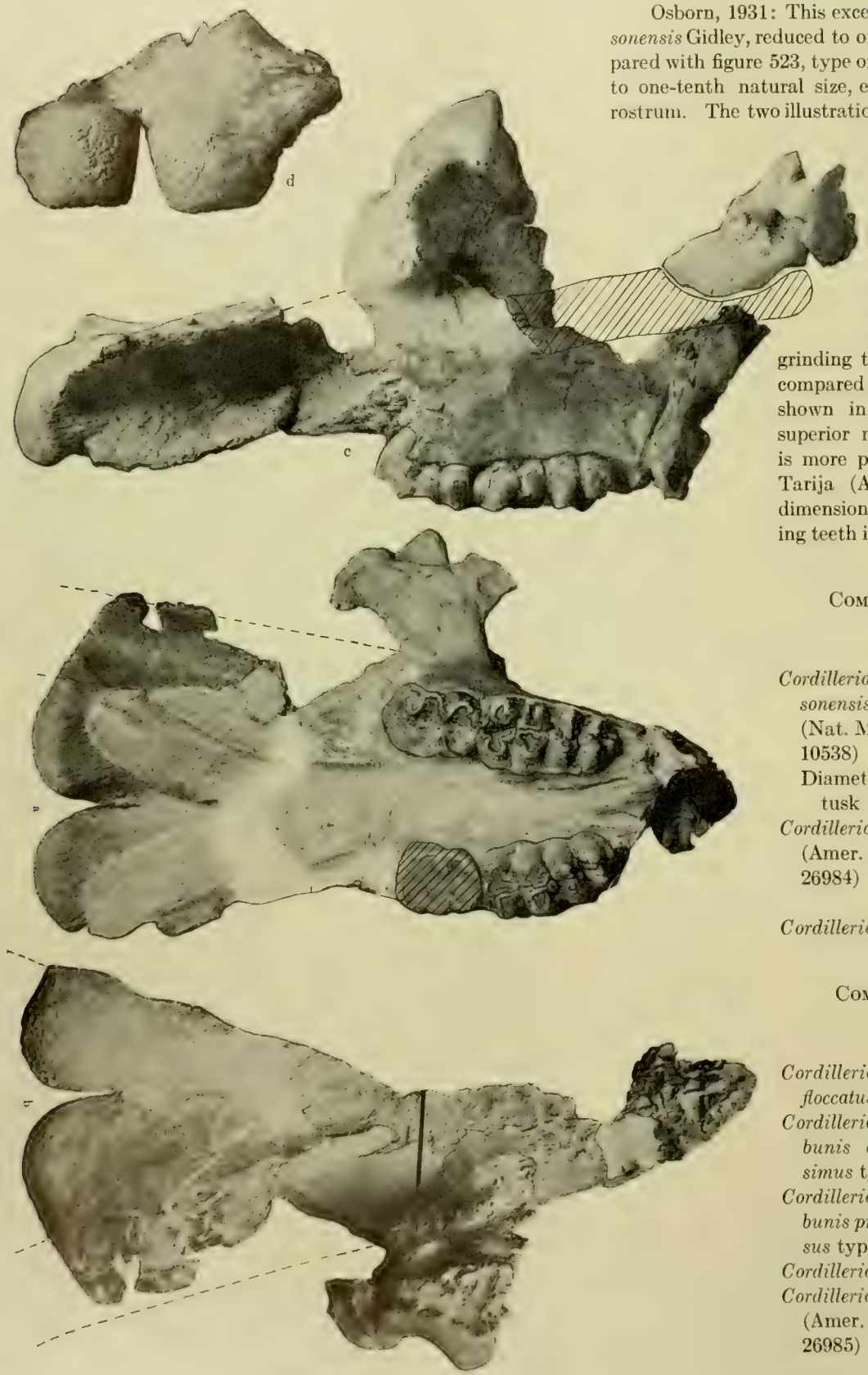
Anancus bensonensis Gidley, 1926. "Fossil Proboscidea and Edentata of the San Pedro Valley, Arizona." U. S. Geol. Surv., Prof. Paper 140-B, pp. 85, 86. TYPE.—(*Op. cit.*, p. 85): "The greater part of the basal portion of a skull from the posterior narial opening forward, including the orbital and zygomatic region, and portions of the squamosal and paraoccipital of one side. The cheek teeth, except right m^2, and part of the alveolar sockets of the tusks are also preserved. Part of this specimen was obtained through exchange from the University of Arizona, and parts were collected by Bryan and Gidley." Nat. Mus. 10538. HORIZON AND LOCALITY.—(*Op. cit.*, p. 85): "About 2½ miles south of Benson, Ariz., in sec. 22, T. 17 S., R. 20 E. . . . Middle or upper Pliocene." TYPE FIGURE.—*Op. cit.*, Pl. XXXII.

TYPE DESCRIPTION.—(*Op. cit.*, 1926, p. 85): "Molars brachyodont, semibunodont; m^2 trilophodont, m^3 tetralophodont with small heel; main cusps of upper molars wearing to trefoil pattern in both rows, but this pattern appears earlier and is better defined in the cusps of the inner side; lophs relatively low and set at right angles to the long axis of the tooth crown; valleys shallow and almost completely blocked medially by the accessory buttresses of the inner row of cusps; rostrum long, very broad, and but little bent down on the plane of the palate, being nearly continuous in direction with it, and seemingly correlated with the possession of nearly straight tusks; palate rather broad and but slightly arched."

Gidley remarks that the present reference of this species to *Anancus* may be considered only provisional; it combines characters belonging to quite distinct genera. It may be compared with the *Anancus arvernensis* of Europe, the *Mastodon andium* of South America, and the *'Tetralophodon shepardi edensis'* of California. The absence of superior tusks and of the lower jaws in the type renders its generic reference uncertain. The principal measurements (*op. cit.*, p. 86) are:

Length of second superior molar, M^2	125 mm.
Width of second superior molar, M^2 (middle loph)	88.5
Length of third superior molar, M^3	191
Width of third superior molar, M^3 (second loph)	99
Estimated diameter of the tusks	130
Basal length of skull from postnarial notch forward	815

REFERRED TUSK.—(Gidley, 1926, p. 85, footnote): "Among other specimens obtained is a mutilated tusk from the Benson locality. This tusk seems with little question to belong to the species of mastodon here described. If so, it entirely corroborates the statement made above, for it is sufficiently well preserved to show that it was about 4 feet long and about 4 inches in diameter and that it is of the nearly straight, twisted variety and possesses a wide band of enamel extending along nearly its entire length. This tusk was found at approximately the same level as that from which the type specimen was taken and only a few hundred feet distant from it. Its form agrees exactly with that of the alveolus in the type of *Anancus bensonensis*."



Type of Cordillerion bensonensis

One-eighth natural size

Fig. 526. Palatal (a), superior (b), left lateral (c), and anterior (d) aspects of the fragmentary type cranium of *Anancus bensonensis* Gidley, 1926 (Nat. Mus. 10538), including parts of the orbit and a fragment of the left squamosal. After Gidley, 1926, Pl. xxxii.

Osborn, 1931: This excellent type figure of *Cordillerion bensonensis* Gidley, reduced to one-eighth natural size, should be compared with figure 523, type of *Cordillerion edensis* Osborn, reduced to one-tenth natural size, especially as to the structure of the rostrum. The two illustrations agree very closely, and if on closer comparison they are found to coincide in detail, the species *Anancus bensonensis* Gidley, 1926, would become a synonym of the species *Dibelodon* [=*Cordillerion*] *edensis* Osborn, 1922. This would be fortunate, as it would afford the much desired knowledge of the structure of the superior grinding teeth shown in figure 526*a*; these grinding teeth and the palate may in turn be compared with those of *Cordillerion andium* shown in figure 528A (palate). The third superior molar of *C. bensonensis* (Fig. 526*a*) is more primitive than that of *C. andium* of Tarija (Amer. Mus. 26984). The relative dimensions of the superior and inferior grinding teeth in these two specimens are as follows:

Comparison of Superior Molars

	M^2		M^3		Tusks
	ap.	tr.	ap.	tr.	
Cordillerion bensonensis type (Nat. Mus. 10538)	125	88.5	191	99	
Diameter of tusk					130e
Cordillerion andium (Amer. Mus. 26984)	r.108	73	r.171	75	
	l.103	72	l.170	75	
Cordillerion gratum	113	83	178	87	

Comparison of Inferior Molars

	M_2		M_3	
	ap.	tr.	ap.	tr.
Cordillerion defloccatus type	110e	100e	230e	101
Cordillerion oligobunis antiquissimus type			155e	
Cordillerion oligobunis progressus type			186	74
Cordillerion orarius	125e	90	223	95
Cordillerion andium (Amer. Mus. 26985)	l.106	69	l.159	76
			r.165	76

4. NEW KNOWLEDGE OF CUVIERONIUS AFFORDED BY RECENT DISCOVERIES IN BOLIVIA (TARIJA) AND IN ECUADOR (NEAR PUNIN AND ALANGASI)

The above Section II, 3, of the present chapter, "Systematic Revision of the Genus *Cordillerion* and its Included Species up to the Year 1927," covering the 120-year period from Cuvier's *Mastodon andium* (1806–1824) to Gidley's *Anancus bensonensis* (1926), reveals on the one hand the wonderful extension of our knowledge, on the other how much remains to be discovered and studied monographically before our knowledge of the anatomy and history of these remarkable mountain-loving bunomastodonts is complete.

The present Section II, 4, may be devoted, therefore, to the knowledge afforded by the recently discovered crania of Tarija, Bolivia, of the Quebrada [canyon] of Chalang near Punin, and of the Quebrada of Cachihuayco near Alangasi, also by the unique skeleton associated with the Alangasi cranium, and by the announcement of Dr. Fr. Spillmann and Dr. Max Uhle that these animals survived in Ecuador into the early historic period of human occupation, namely, about 1800–1600 years ago.

The new species described by Spillmann are:

Tetrabelodon (*Bunolophodon*) *Ayora*, 1928 1931, Quebrada [canyon] of Chalang near Punin, Province of Chimborazo, Ecuador..... = *Cuvieronius ayoræ* of the present Memoir

Bunolophodon postremus, 1928 1931, Quebrada [canyon] of Cachihuayco near Alangasi, Province of Pichincha, Ecuador..... = *Cuvieronius postremus* of the present Memoir

The important discovery of *'Bunolophodon' postremus* near Quito, Ecuador, as communicated to the Palæontological Society of Budapest, September–October, 1928, and published in the Palaeontologische Zeitschrift, Band II, July 22, 1929, following a preliminary communication in "Natur und Museum," Heft 2, 1929, adds not only to our knowledge of the complete associated skeletal characters of *Cuvieronius*, as repre-

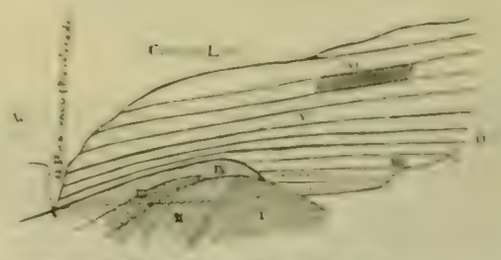
Die Quebrada von Chalang in den Bergen von Licto.

Fig. 527. Localities of Mastodont Discoveries in Ecuador, in the Canyon of Chalang, near Punin, Province of Chimborazo.

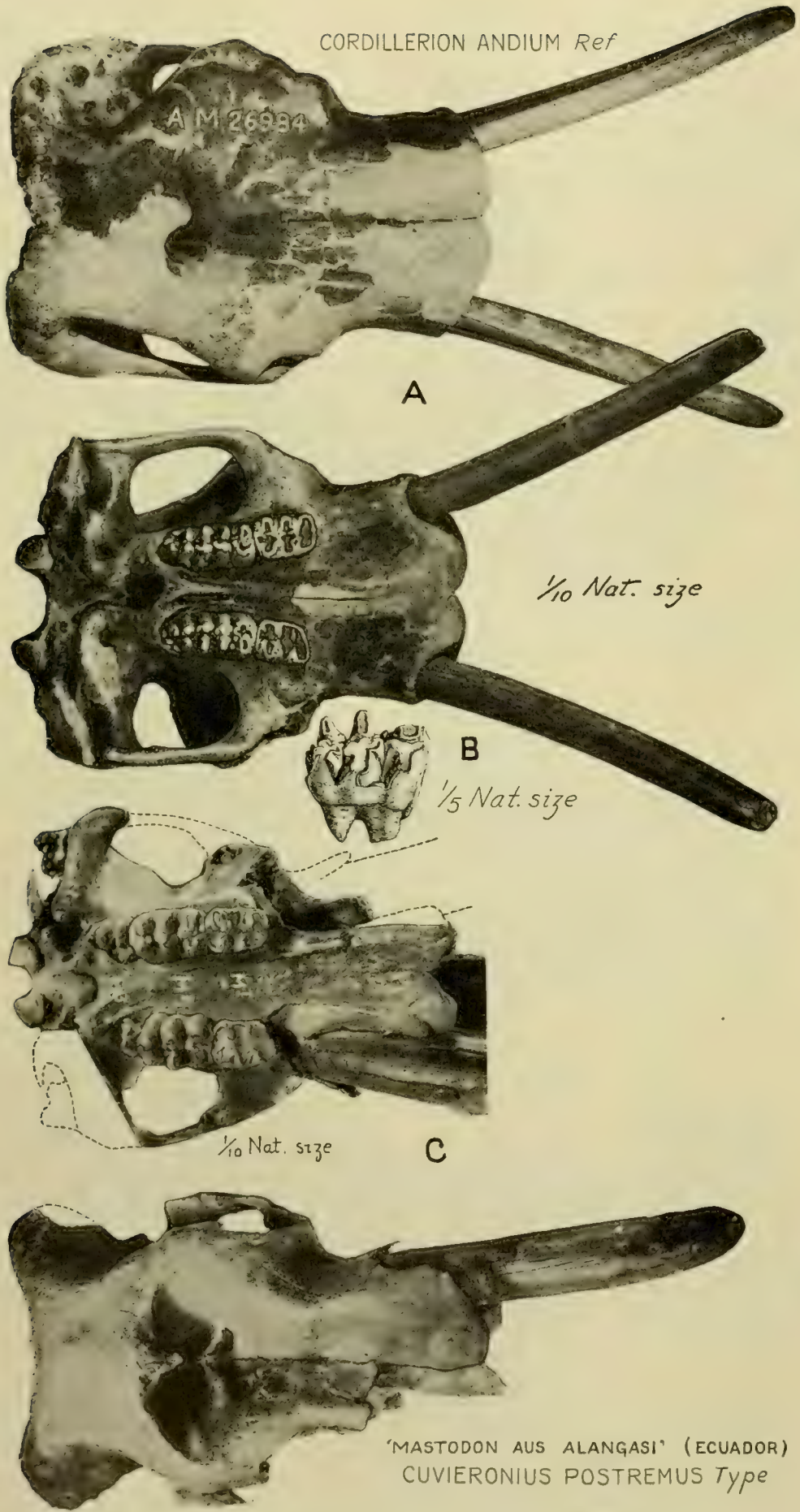
After Spillmann, 1931, p. 9

(Upper) Canyon of Chalang in the Cerro de Licto, which yielded the type of *'B.'* [*Cuvieronius*] *ayoræ* Spillm. (Spillmann, 1931, p. 67): "Der eine, bestehend aus einem fast kompletten Schädel und diversen Extremitätenknochen, stammt aus der Quebrada von Chalang, nahe dem Indianerdorfe Punin, in der Provinz Chimborazo. Die geologischen Verhältnisse dieser Fundstelle habe ich schon Eingangs erwähnt, das Alter dieses Fossils ist pleistocaen. . . . Aus den pleistocaenen Schichten der Tuffe von Chalang, liegt mir ein fast vollständiger Mastodonschädel, ebenso diverse Skelettknochen desselben Individuums vor."

(Lower) Geologic profile of the Canyon of Chalang: (I) Syenite, (II) crystalline slate, (III) conglomerate, (IV) fine-grained sandstone, (V) recent volcanic tuff, (VI) Lapilli beds, (VII) waterfall, a–b, xxx fossil layers.



Geologisches Profil der Quebrada von Chalang.
I Syenite, II Kristallinische Schiefer, III Konglomerate, IV Feinkörniger Sandstein, V. Jungvulkanische Tuffe, VI. Lapillischichte, VII Wasserfall, a–b Der Bachlauf, xxx Fossilien



A–C. SUPERIOR AND PALATAL VIEWS OF TARIJA AND ALANGASI CRANIA

A. Referred Cranium of Cordillerion andium, Tarija, Bolivia
One-tenth natural size

Fig. 528. Superior and palatal views of cranium, Tarija, Bolivia, collected by E. S. Riggs, Field Museum Expedition of 1926 (Field Mus. P.13643), presented in exchange, 1929, (=Amer. Mus. 26984); right superior tusk preserved, left superior tusk restored. Observe single internal trefoils; that r.M^2 agrees closely in character and size with Cuvier's type of *'Mastodon' andium* (Fig. 529B) the genotypic species of *Cordillerion* Osborn.

B. Cuvier's Type of Mastodonte des Cordilières from near Quito, Ecuador, Humboldt Collection

Fig. 529. Cuvier's type figure of *Mastodonte des Cordilières*, 1806; *'Mastodon' andium*, 1824. An r.M^2, reduced to one-fifth natural size. Observe that Cuvier's type of *'Mastodon' andium* was recorded by Humboldt as having been found near Quito, Ecuador, and that it agrees very closely in character and size with r.M^2 in Amer. Mus. 26984 (see adjoining Fig. 528).

C. Type Cranium of Bunolophodon [=Cuvieronius] postremus Spillmann, 1929, 1931
'Mastodon of Alangasi,'
Ecuador. Mus. Univ.
Cent. Ecuador
One-tenth natural size

After photographs retouched. Compare Spillmann, 1929.2, Abb. 3, 4, also 1931.1

Fig. 530. Cranium discovered by Fr. Spillmann, April, 1928, 13 km. east of Quito, near the Indian village of Alangasi (Spillmann, 1929, p. 171): "ein vollständiges Skelett eines Mastodonten auf primärer Lagerstätte, vergesellschaftet mit Tonscherben, Feuerstellen und Lanzenspitzen, als Beweis der Anwesenheit des Menschen und seiner Beziehungen zu jenem subfossilen Tier. Den ausführlichen Fundbericht mir vorbehaltend, beschränke ich mich hier auf die wichtigsten Tatsachen: Die geologischen Verhältnisse der Fundstelle liegen sehr einfach und klar. Die weitverbreiteten, mächtigen vulkanischen Tuffe, die bekanntlich in ihren untersten Schichten die Reste einer pleistozänen Fauna enthalten, bilden hier die Unterlage eines blauen Tones von ungefähr 1,5 m Stärke. Dieser blaue Ton ist nur eine örtliche Ablagerung fluviatiler Natur auf einer 2 m hohen Terrasse am linken Ufer des kleinen Flüsschens Cachihuaco."

(Spillmann, 1931, p. 67): "Der zweite Funde ['*B.*' *postremus*] wurde bei dem Dorfe Alangasi, 13 km. östlich von der Landeshauptstadt gemacht, wo ich ein fast komplettes Skeletbergen konnte. Das Alter dieses Fundes konnte einwandfrei festgestellt werden, da zusammen mit diesem Mastodon menschliche Artefakte, wie Topfscherben und Feuerstellen gefünden wurden." Compare full description and figures on page 585.

sented in the new and rather primitive species '*Bunolophodon*' *postremus* (MS., letter from Dr. Spillmann, June 6, 1930), but presents extremely important evidence of the survival of *Cuvieronius* into the period of human occupation of Ecuador. These facts were presented before the Twenty-third International Congress of Americanists, September, 1928, by Dr. Max Uhle, under the title "Späte Mastodonten in Ecuador," practically at the same time as Doctor Spillmann's communication to the Palæontological Society of Budapest, September–October, 1928. As fully set forth below, the discovery of this locality 13 km. east of Quito was made by Doctor Spillmann in April, 1928.

Additional Cranial and Dental Characters of Cordillerion and Cuvieronius

The accompanying illustrations (Figs. 528, 529, 530, 531, 532, 533, 534, 535), partly reproduced from Carette's Memoir of 1919, partly from Spillmann's papers of 1929, 1931, and partly original from the new Tarija cranium (Amer. Mus. 26984, 26985), are especially assembled to display more clearly than has been done before the superior, the palatal, and the lateral aspects of the cranium, tusks, and grinding teeth in the juvenile (Fig. 530) and in the mature (Figs. 528, 532A) stages of these two genera.

Fig. 531. Cuvieronius Grinding Teeth and Tusks, Type and Referred

After Carette (1919, Lám. xi, xii), one-third and one-twentieth natural size respectively

Grinding Teeth. Supero-internal trefoils larger and more worn; infero-external trefoils larger and more worn.

6, Referred third superior molar, r.M^3, of *Cuvieronius humboldtii*. Double trefoils, 4⅓ ridge-crests. [= *C. superbus*.]

7, Referred third superior molar, l.M^3, of *Cuvieronius superbus*. Double trefoils; 4½ ridge-crests. Compare Cabrera, 1929, fig. 29 (Fig. 561 of the present Memoir).

8, Referred convexo-concave third inferior molar, l.M_3, of *Cuvieronius platensis*. 5½ ridge-crests. Compare Cabrera, 1929, fig. 16 (Fig. 560 of the present Memoir).

9, Referred biconvex third inferior molar, l.M_3, of *Cuvieronius platensis*. 5¼ ridge-crests.

10, Fragment of referred inferior molar of *M.* [*Notiomastodon*] *argentinus*.

Tusks.

3, Type incisive tusk of *Cuvieronius rectus*, after Ameghino, 1889 (in Carette).

4, Type incisive tusk of *Cuvieronius superbus* [cf. *C. bonaerensis* Mor., 1888], after Ameghino, 1889 (in Carette).

5, Referred tusk of *Cuvieronius humboldtii*, after Ameghino, 1889 (in Carette). [= *C. platensis*.]

Ridge-Crests. The reproduction of Cuvier's type second superior molar (Fig. 529B) is placed side by side with the corresponding r.M^2 of the Tarija cranium (Fig. 528) and of the Alangasi cranium (Fig. 530), thus firmly establishing Cuvier's classic type description. The crown enamel ridges of the superior (Figs. 528, 530) and inferior (Fig. 532A) molars are purposely retouched in white the better to display the characteristic ridge-crests of M^1, M^2, M^3, and of M_2, M_3. Contrary to the usual principle, M_3 is somewhat less progressive than M^3; also in M^1 (Fig. 530) the anterior ridge-crest is imperfectly developed. The ridge formula seems to be as follows:

M 1 $\frac{3}{\ }$ M 2 $\frac{3}{3}$ M 3 $\frac{4\frac{1}{2}}{4\frac{1}{2}}$

Comparison of Tusks and Enamel Band.—The tusks of the young Alangasi male (Fig. 530) are relatively short and robust, without enamel band, less widely divergent. The tusks of the Tarija male (Fig. 528) are divergent, outcurved and slightly downcurved (Fig. 532A), with an exceptionally *narrow* enamel band.

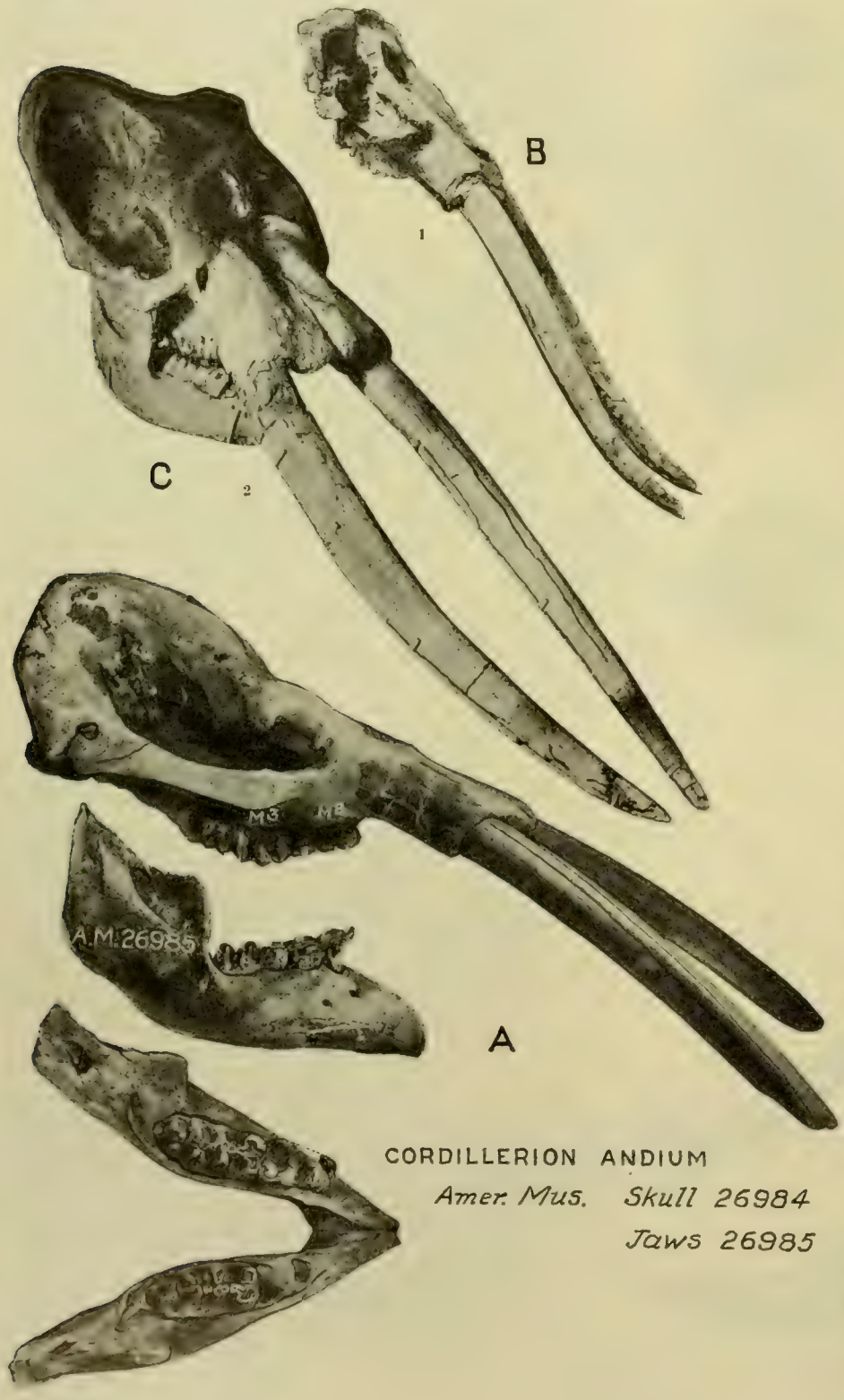


Fig. 532. A–C. Lateral Views of Crania of Cordillerion (A, B) and of Cuvieronius (C)

(B) After Nordenskiöld. (C) After Carette. (A) Osborn original

B, *Cordillerion andium.* Incomplete cranium from Tarija, with long incisive tusks, slightly upturned at extremities, spiral enamel band. After Nordenskiöld (Carette, 1919, Lám. xi, fig. 1), one-twentieth natural size. Same male cranium shown in figure 507 of the present Memoir.

C, *Cuvieronius bonaerensis* [=*superbus*] type. Lower Pampean. Restored male cranium from Arrecifes, Province of Buenos Aires, Argentina, with long, straight, and slightly incurved incisive tusks, without enamel band. After Carette, 1919, Lám. xi, fig. 2, one-twentieth natural size, as *Dibelodon platensis.* Same cranium shown in figure 542 of the present Memoir as the type of *Mastodon* [*Cuvieronius*] *bonaerensis* Moreno; by Cabrera (1929) referred to *Stegomastodon platensis* (see p. 579 of the present Memoir).

A, *Cordillerion andium.* Referred male cranium from Tarija, Bolivia (Amer. Mus. 26984). The superior and palatal aspects of this cranium are shown in figure 528A to the same one-tenth scale. Jaws of another individual (Amer. Mus. 26985). Observe unworn external trefoils in M_3, infero-external trefoils larger, more worn, tetralophodont, plano-convex; rostrum pointed, extreme length 672 mm. Third right inferior molar, r.M_3, 165 × 76 mm. (Amer. Mus. 26985); third right superior molar, r.M^3, 167×76 mm. (Amer. Mus. 26984).

Comparison of Crania.—The facio-premaxillary region of the young Alangasi cranium (*Bun.* [=*Cuvieronius*] *postremus*—Fig. 530) is more elongate and relatively narrower than that of the adult Tarija cranium (Fig. 528A) in which the facio-premaxillary region is relatively shorter and broader. All the *Cordillerion* crania (Figs. 528 and 532A, B) and the cranium of *Cuvieronius postremus* (Figs. 530C, 551) are much smaller and shallower than the cranium of *Cuvieronius bonaerensis* (Fig. 532 C).

Type Cranium and Skeleton of 'Bunolophodon' [=Cuvieronius] postremus of Alangasi, Ecuador, and Type Cranium of 'B.' [=Cuvieronius] ayoræ of Punin, Ecuador

The above illustrations of the Alangasi cranium (Fig. 530C) may be supplemented by photographs of the unique type skeleton (Fig. 533), also by the following citations from Spillmann's original description (1929) of the discovery of the 'Mastodon aus Alangasi' which he presented before the Palaeontological Society of Budapest, September–October, 1928, and from his letters dated Quito, June and July, 1930, referring as well to his species '*Bunolophodon* [=*Cuvieronius*] *Ayora*' of 1928.

Spillmann, 1929.2, pp. 171–177. Compare Spillmann, 1931, pages 73–76

Im April dieses Jahres fand ich ungefähr 13 km östlich der Landeshauptstadt Quito bei dem kleinen Indianerdorfe Alangasi, ein vollständiges Skelett eines Mastodonten auf primärer Lagerstätte, vergesellschaftet mit Tonscherben, Feuerstellen und Lanzenspitzen, als Beweis der Anwesenheit des Menschen und seiner Beziehungen zu jenem subfossilen Tier. Den ausführlichen Fundbericht mir vorbehaltend, beschränke ich mich hier auf die wichtigsten Tatsachen:

Die geologischen Verhältnisse der Fundstelle liegen sehr einfach und klar. Die weitverbreiteten, mächtigen vulkanischen Tuffe, die bekanntlich in ihren untersten Schichten die Reste einer pleistozänen Fauna enthalten, bilden hier die Unterlage eines blauen Tones von ungefähr 1,5 m Stärke. Dieser blaue Ton ist nur eine örtliche Ablagerung fluviatiler Natur auf einer 2 m hohen Terrasse am linken Ufer des kleinen Flüsschens Cachihuaco. Dieser jungfluviatilen Tonschicht liegt das erwähnte *Mastodon*-Skelett auf; bzw. es ist teilweise durch sein Gewicht in den Ton eingedrückt.

Das *Mastodon* lag auf seiner linken Seite, den Kopf erhoben mit weitgeöffnetem Maul, die Extremitäten weit von sich gestreckt. Rings um das Skelett fanden sich Feuerstellen in unmittelbarer Berührung mit dem Tiere wie auch in der Bauchhöhle selber vor. Durch das mächtige Feuer, das die Jäger jenes Riesen angemacht hatten, um ihn zu braten, ist der Ton um das Tier herum hart gebrannt, wodurch er ziegelähnliche Form und Farbe angenommen hat. Die Knocken des Skelettes zeigen an sehr vielen Stellen Verkohlungen, was die Konservierung des Fundes sehr erschwerte. . . .

Die Untersuchung der Tonscherben hatte nun das ganz überraschende Ergebnis, dass sie einer primitiven Kultur zugezählt werden müssen, jedoch mit stark majoiden Kultureinflüssen. Die Archäologen sind so weit gegangen, dass sie das Alter der Scherben, die mit jenem Mastodonten vergesellschaftet waren, auf 1600 bis 1800 Jahre geschätzt haben.

Um das Bild der Fundstelle zu vervollständigen, erwähne ich weiter, dass das Deckmaterial sekundär eingestürzten Erdreiches von einer höheren Terrasse stammt, was auf den ersten Blick aus dem Material selbst zu erkennen ist. Die Fundstelle umfasst eine Fläche von 60 qm, ist also sehr lokalisiert. Diesem kurzen Fundbericht will ich noch einige bemerkenswerte Einzelheiten beifügen. So fand ich z. B. in der Gegend des Beckens, wo das Rektum zu liegen kam, eine grössere Menge von sehr gut erhaltenen Kotballen von ungefähr 18 cm Durchmesser, kugelrunde Ballen von der Konsistenz des Pferdekotes. Von grösserer Bedeutung sind die Verletzungen am Schädel des Tieres, die nach den Gutachten von Fachleuten nur durch spitze, lanzenförmige, harte Gegenstände, hervorgerufen sein können. Es ist daher ziemlich einwandfrei, dass für derartige Verletzungen bloss die Steinlanze in Betracht kommt. Wir sehen somit, dass man dem Riesentiere wohl mit der Steinlanze nachgestellt hat, dass diese aber nicht ausreichend war, um das Tier zu töten, da die Verletzungen verheilt sind.

Man kommt also zu der Frage, wie eigentlich das Tier von jenen Jägern getötet wurde. Auch darüber gibt mein Fundbericht Aufschluss. Das Skelett befand sich in vollständigem Verband. Nur die Halswirbelsäule zwischen Epistropheus und dem ersten Brustwirbel wies eine Zertrümmerung auf; es lag auf dieser Stelle ein runder Stein von ungefähr 40 cm Durchmesser, der von den Jägern aus der höheren Terrasse auf das in die Schlucht getriebene Tier niedergeschleudert wurde und ihm den Todesstoss versetzte. Denn obgleich die Halswirbel zertrümmert waren, befanden sie sich doch in ihrer ursprünglichen Lage, was eine postmortale Zertrümmerung ausschliesst. Um das Tier auch von der Unterseite her zu braten, haben die Jäger das getötete Tier mit dicken Stangen am Becken zu heben versucht, was ihnen aber bloss zum Teil gelungen war, da die Hebestangen abbrannten und so der niederfallende Körper das Feuer unterdrückte und die nur zum Teil verkohlten Stangen bedeckte.

An dem sonst vollständigen Skelette fehlen die rechten Rippen vollkommen, was ich mir dahin erkläre, dass dies eben die Teile waren, die von den Jägern verzehrt wurden, während die überbleibenden Knochen weggeworfen wurden. Im Tone konnte ich auch den naturgetreuen Abdruck des Abdomens und des Brustkorbes feststellen und messen.

Bei der Bearbeitung des Materials nach seiner Bergung kam ich auf weitere interessante Beweise für die Anwesenheit des Menschen. Es sind dies die schon erwähnten verheilten Verletzungen an der rechten Seite des Hinterschadels (Abb. 2), wo die eine 2 cm, die andere 6 cm von der Occipitalcrista entfernt liegen. Die näher gelegene Verletzung hat einen äusseren Durchmesser von 27 und 25 mm, der Fistelkanal 10 zu 11 mm. Der Aussenrand dieser Verletzung ist ringsherum mit Kallusbildungen überzogen, so dass die Ränder der Verletzung abgerundet bzw. wulstig erscheinen. An dem Rande gegen das vordere Ende des Kopfes hin erkennt man in dem Kallus einen Schnitt der von der eindringenden Lanzenspitze herrühren dürfte. Der

Fistelkanal ist sehr tief, da er in eine Luftkammer einmündet. Die zweite Knochenverletzung zeigt mit weit mehr Deutlichkeit die Verletzungsursache. Quer durch dieselbe geht ein tiefer Schnittkanal von 50 cm Länge, dessen Wände sich an der Basis in einen spitzen Winkel treffen, somit einen deutlichen Abdruck dessen ergeben, was die Verletzung hervorgebracht hat, nämlich der Lanze. In diesem Falle misst der Fistelkanal 21 : 23 mm an seinem äusserem Rande und 12:12 mm im Kanale selbst; seine Tiefe ist 25 mm. Auch an dieser Verletzung sind starke Kallusbildungen nachzuweisen. Die beiden Verletzungen sind 5 cm voneinander entfernt, die Schnittkanäle, also die eigentlichen Verletzungen, werden gegen die Mitte zu immer tiefer.

Wir sehen daraus ausserdem, dass eine nicht mehr ganz primitive Kulturstufe notwendig war, um grosse Tiere ausrotten zu können. Ich verweise auf das Mammut Europas, das daher im Magdalen ausgerottet werden konnte, während leichter jagdbare Tiere vielleicht schon früher zum Aussterben gebracht wurden.

Was nun das *Mastodon* selber betrifft, so sei hier auch nur eine kurze Beschreibung gegeben.

Das Skelett ist derart vollständig, dass sich jedwede Untersuchungen und Messungen anstellen lassen. Da es mir an Literatur sehr mangelt, so habe ich es vorgezogen, jenen Mastodonten aus Alangasi mit einem von mir schon früher gefundenen *Mastodon*-Schädel zu vergleichen, der ebenfalls fast vollständig ist und der in den Schichten gefunden wurde, die man als pleistozän angenommen hat. Bei diesem Vergleiche kamen sehr interessante Ergebnisse zutage, die uns abermals einen Beweis erbringen, dass es sich bei dem *Mastodon* aus Alangasi tatsächlich um ein viel höher spezialisiertes Exemplar handelt. Für die Nennung von Zahlen ist hier nicht der Ort; es seien nur die wichtigsten Unterschiede kurz angegeben.

Wir finden weitgehende Verschiedenheiten am Schädel, im Verhältnis des Kranialteiles zum Visceralteil. So fand ich am geologisch älteren Schädel einen kleineren, resp. kürzeren und schmäleren Hinterschädel, während der Gesichtsteil viel länger ist. Dass diese Unterschiede nicht gering sind, zeigen uns die Zahlen. Bei der Form aus Riobamba, der geologisch älteren Form, misst bei gleicher Schädelbreite von 52½ cm der Abstand von der Occipitalcrista bis zur Spitze des Rüsselfortsatzes 27 cm, bei der Alangasi-Form aber 31 cm. Der Abstand von der Spitze des Rüsselfortsatzes bis zum Vorderrande der Nasalen dagegen misst bei der primitiveren Form 65 cm, bei der Alangasi-Form aber nur 59 cm. Auch die Form des Schädels im allgemeinen ist sehr verschieden; so zeigt uns das *Mastodon* aus Alangasi ein viel steileres Gesamtprofil und die Nasalen steigen gegen ihr vorderes Ende zu mehr nach aufwärts, an ihrem Übergange förmlich eine Mulde bildend. Das Profil des Mastodonten aus pleistozänen Ablagerungen dagegen ist mehr geradlinig; denn es fehlt jene Abknickung der Nasalen und die Mulde, die die Alangasi-Form bezeichnet.

Die Stosszähne reichen bei der Alangasi-Form viel weiter unter die Ebene der Kaufläche, was durch den Profilwinkel bedingt wird. Auch die Form der Zähne, besonders der Stosszähne, auf die frühere Autoren so grossen Wert legten, ist bei der von mir zuletzt gefundenen Form sehr bezeichnend. Der Umfang der Stosszähne ist bei dem *Mastodon* aus Alangasi bedeutend grösser als bei der älteren Form aus Riobamba, wie auch die allgemeine Gestalt der Stosszähne bei beiden Formen sehr variiert. Verschieden von der Form *Bunolophodon andium* sind die Stosszähne bei den von mir gefundenen Formen, denn sie sind geradlinig und weisen bloss eine einfache Krümmung nach oben auf, während bei der Form *andium* eine S-förmige Krümmung bei spiralförmiger Drehung zu sehen ist. Die Stosszähne sind aber bei der Alangasi-Form weit mehr seitlich abgeflacht und ihr vertikaler Durchmesser weit grösser. Einige Masse erläutern dies besser. Die Verhältniszahl vom vertikalen zum horizontalen Durchmesser ist z. B. bei einer Entfernung von 20 cm von der Spitze bei der älteren Form 9 : 6½, bei der jüngeren Form 9,7 : 9,6, dagegen 60 cm von der Spitze beim Mastodonten von Alangasi 17,5 : 11,5 und bei der pleistozänen Form aus Riobamba 13,4 : 11,6.

Spillmann, letter, June 6, 1930

Zurueckkommend auf den Inhalt Ihres Schreibens, sende ich Ihnen gleichzeitig mit dieser, auch das Separatum meines Vortrages vom Palaeontologenkongress von Budapest aus dem Jahre 1928, das den vorlaeufigen Bericht ueber *Bunolophodon postremus* aus Alangasi in Ecuador enthaelt. Die monographische Beschreibung der von mir gefundenen zwei neuen Mastodonformen, erfolgt in kuerzester Zeit und befindet sich das Manuskript fast druckfertig zum Absande bereit.

Skeleton of Cuvieronius postremus Spillmann, 1929–1931

Fig. 533. Skeleton of '*Bunolophodon*' *postremus* Spillmann (Mus. Univ. Cent. Ecuador), about one-twentieth natural size. After Spillmann, 1929.2, fig. 1. Compare type cranium, one-tenth natural size, in figure 530, also in figure 551.

The skeleton is remounted as nearly as possible in the position in which it was originally found, namely, lying on its left side, the head raised, with widely opened mouth, and the extremities extended, as fully described with a number of measurements in the accompanying abstract of Spillmann's article (1929.2, pp. 171–177).

In dieser vorgenannten Arbeit, konnte ich den Beweis erbringen, dass die von mir gefundenen Mastodonten tatsaechlich zwei ganz verschiedenen Species angehoeren, verschieden von *B. Andium* und ebenso *B. Humboldtii* sei es im Bezug auf die Form als auch auf ihre relativen Masse. Die von mir als *B. Ayorae* beschriebene Form stuende himit ungefahr zwischen den beiden von Ihnen genannten, waehrend die phylogenetische Stellung von *B. Postremus* die von *B. Humboldtii* weit uebertrifft.

B. Ayorae ist pleistozaen waehrend *B. postremus* prachistorisch.

Einen Jagdplatz den ich vor kurzer Zeit ausgegraben habe, der nach M. Uhle der selben Zeitperiode angehoeren duerfte wie der eben erwaehnte Mastodonfund von Alangasi, beinhaltet ausser der Form *B. postremus* ebenfall *Neohippus Andium* und *Mylodon robustus* Ow., neben einer Unzahl von Scherbenresten, wodurch ich auch den Beweis erbringen konnte, dass dieser Equide auch prachistorischen Alters ist.

Leider haben wir hier in Ecuador nicht die hinreichenden Mittel, alle meine Studien zu publizieren, so dass noch sehr wenige veroeffentlicht werden konnten.

Spillmann, letter, July 2, 1930

Die andere neue, von mir beschriebene Form, die Sie in Ihrem Manuskripte als Mastodon vom Chimborazo aus der Arbeit von Boule zitieren, ist aber ebenfalls ein *Cuvieronius* und wurde von mir als *Bunlophodon Ayorae* beschrieben. Diese letztere Form stellt einen entwicklungsgeschichtlich primitiveren Typus dar als mein *B. postremus*, wie ich dies in einer vergleichenden Beschreibung beider Formen beweisen konnte, da beide Formen an Hand eines fast vollstaendigen Schaedels, eine genuegende Unterlage darboten.

Unfortunately the manuscript of the promised Memoir[1] on '*Bunolophodon*' *postremus* and '*B.*' *Ayoræ*, together with measurements and full description of the skeleton, was partly destroyed by fire in the buildings of the University of Ecuador, thus Doctor Spillmann's detailed observations on '*Bunolophodon*' *postremus* and final conclusions and measurements were not received in time to fully include them in the present chapter.

Osborn, 1931: The substance of the above letters covers ten principal points (1–10), as follows:

(Spillmann, June 6, 1930) In my monographic description (subsequently partly destroyed by fire) the two mastodonts actually represent two wholly different species, distinct both in form and in relative size from *Bunolophodon andium* as well as from *B. humboldtii*. (1) The stage described as *B. Ayoræ* stands approximately intermediate between the above Cuvierian species, while the phylogenetic rank of *B. postremus* far surpasses that of *B. humboldtii*. (2) In geologic age *B. Ayoræ* is Pleistocene, while *B. postremus* is prehistoric. (3) Belonging to the same prehistoric age is a hunting place that I have recently excavated which, according to Doctor Uhle, is referable to the same prehistoric age as the *B. postremus* of Alangasi. Besides *B. postremus* this hunting place contains *Neohippus andium*, also *Mylodon robustus* Owen, in addition to a number of pottery remains, which prove that this species of horse (*N. andium*) is also of prehistoric age. (4) My monograph will contain all the desired measurements in comparative form as well as a complete description of the crania.

(Spillmann, July 2, 1930, on receipt of proofs of Osborn's Chapter XII) (5) I believe in a monophyletic rather than a polyphyletic evolution of the mastodonts of South America out of the '*M.*' *andium* type.

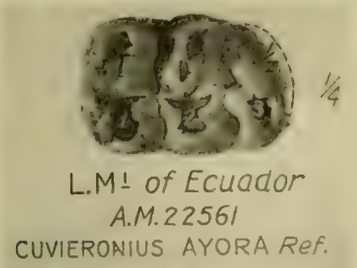


Fig. 534. *Cuvieronius ayoræ* ref. Left superior molar, l.M¹ (Amer. Mus. 22561), from canyon 10 meters below surface, near Quito, Ecuador; purchased April, 1930. Narrow; external trefoils large; internal trefoils rudimentary; 121×79 mm.

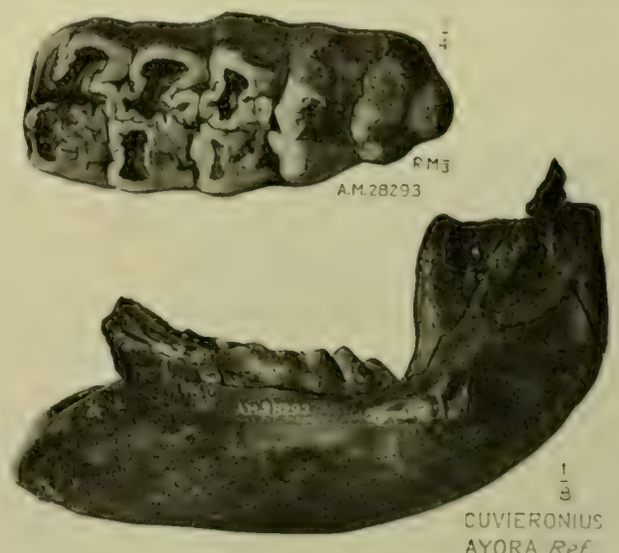


Fig. 535. *Cuvieronius ayoræ* ref. Right third inferior molar, r.M₃, and mandible with right and left M₂, M₃, *in situ* (Amer. Mus. 28293), from south of Guayaquil, Ecuador. Frick Coll., 1931. M₃ with 5½ ridge-crests, external trefoils large, internal trefoils rudimentary, as in figure 534, 240×101 mm. Molar one-fourth, mandible one-eighth natural size.

[1]Spillmann, Franz, "Die Säugetiere Ecuadors im Wandel der Zeit," Quito, 1931, Erster Teil, 112 pages, 25 figures. This invaluable Memoir fully confirms and extends our palæontological knowledge by these epoch-making discoveries, including the fauna of the Pleistocene of Ecuador.

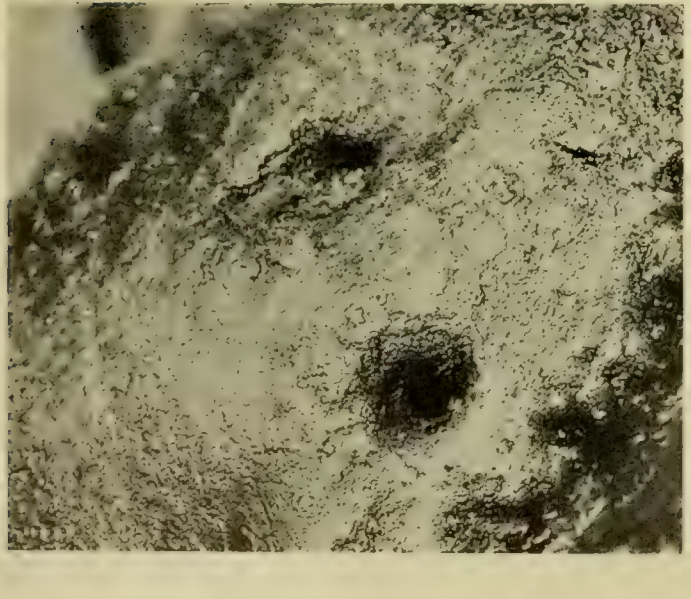
(6) According to the Osborn nomenclature the *Bunolophodon postremus* of Ecuador should be designated, however, as *Cuvieronius* rather than as *Cordillerion*, a species which survived into the Christian era as a hunting object of the primitive Indian people. (7) The other new species that I have described [*Ayoræ*], which includes the "Mastodon von Chimborazo" [Dr. Proano's specimen] cited from Boule, is certainly a *Cuvieronius* and was described by me as *Bunolophodon Ayoræ;* this latter stage, *B. Ayoræ*, stands as more primitive than my *B. postremus*, a fact which I can demonstrate in my comparative description of these two species, grounded on the almost complete skulls [Figs. 530, 548, 549, 551] which afford full knowledge. (8) In this description Boule's principle is adopted, that we must rely in most cases on the structure of the cranium rather than on the foldings (trefoils) of the enamelled teeth; (9) on the other hand, a type, according to the Osborn system designated as *Cuvieronius*, lived on the Cordilleran plateau, a fact in opposition to Boule's opinion. (10) As expressed in the above letters, Spillmann (1930) considers *B. postremus* as intermediate between *B. andium* and *B. humboldtii* but relates both species rather to the *Cuvieronius* than to the *Cordillerion* type. Osborn (1931) accordingly provisionally includes *Tetrabelodon* (*Bunolophodon*) *Ayoræ* Spillmann, 1928–1931, and *B. postremus* Spillmann, 1928–1931, within the *Cuvieronius* phylum of the present Memoir.

Archæological Confirmation by Dr. Max Uhle (1930).—As noted above, Doctor Uhle was summoned to the scene of the discovery of *'Bunolophodon' postremus* and in his report before the Twenty-third International Congress of Americanists, September, 1928, he not only fully confirmed Doctor Spillmann's observations but added full archæological details as to the presence of obsidian flints, carved bone implements, decorated pottery, and other evidences of the relatively recent prehistoric age of the Alangasi Mastodon. As to the evidence of fire Uhle observes (*op. cit.*, 1930.1, pp. 253, 254):

> Das Feuer hatte aber nicht nur die Reste des Tieres auf allen Seiten umgeben, sondern auch dessen Skelett an den verschiedensten Stellen beschädigt. Brandspuren am Skelett fanden sich an der Hinterseite des Schädels, an verschiedenen Seiten des Beckens, am rechten Fusse. Die Schwanzwirbel, dicht eingehüllt in eine harte rot gebrannte Schicht von Lehm, waren zum Teil verkohlt. Die letzten drei Wirbel fehlten, als verbrannt, sogar ganz. An ihrer Stelle gewahrte man nur graue verbrannte Erde. Über die Absichtlichkeit der Feueranmachung rund um den Schwanz konnten keine Zweifel entstehen. Ebenso war Feuer absichtlich in der Bauchhöhle angemacht worden. Verschiedene Knochen in derselben zeigten Spuren von Feuer. Einige der linken Rippen waren angekohlt, das Brustbein sogar vollständig verbrannt, jedoch in diesem Zustande erhalten. Man würde ratlos sein, zu vermuten, aus welchem Grunde an so verschiedenen Seiten des Körpers Feuer vom Menschen angezündet worden war, wenn nicht auch andere Reste von ihm überall in der Feuerschicht gefunden worden wären.

Fig. 536. Supposed Flint Spear Holes in the Occiput of Cuvieronius postremus. After Spillmann, 1929–1931

Die Verletzungen:



Die schon erwähnten Verletzungen befinden sich an der rechten Seite des Hinterschädels; es sind ihrer zwei und liegen seitlich 2, beziehungsweise 6 cm von der Crista occipitalis. Die näher gelegene Verletzung hat einen Durchmesser von 27 und 25 mm, der Fistelkanal ist 10 bis 11 mm tief. Am Aussenrande dieser Knochenverletzung finden wir ringsherum Kallusbildungen, wodurch die Ränder mehr abgerundet und wulstig erscheinen. An jenem Rande, der gegen das vordere Ende des Kopfes orientiert ist, erkennt man in dem Kallus einen Schnitt, der von der eindringenden Lanzenspitze herrühren dürfte. Der Fistelkanal ist sehr tief, tritt aber noch in eine Luftkammer ein. Die zweite Verletzung des Schädelknochens zeigt mit weit grösserer Deutlichkeit die Ursache, aus der sie entstanden war. Quer durch dieselbe geht ein tiefer Schnittkanal von einer Länge von 50 mm, dessen Wände sich an der Basis in einem spitzen Winkel treffen, wodurch sie einen deutlichen Abdruck einer Lanzenspitze erkennen lassen. Hier misst der Fistelkanal 21 bis 23 mm im Querschnitte, bei einer Tiefe von 25 mm. Auch an dieser Verletzung sind starke Kallusbildungen wahrzunehmen. An beiden Lanzenverwundungen aber finden wir, dass die Schnittkanäle gegen ihre Mitte hin immer tiefer werden, bis sie schliesslich in den eigentlichen Fistelkanal einmünden.

5. SYSTEMATIC REVISION OF THE GENUS CUVIERONIUS UP TO THE YEAR 1935

HUMBOLDTIDÆ fam. nov.[1] HUMBOLDTINÆ Osborn, 1934

Original reference: Journ. Mamm., XV, No. 3, August, 1934 (Osborn, 1934.924, fig. 2), name only; Proc. Amer. Phil. Soc., LXXIV, No. 4, August, 1934 (Osborn,1934.926, fig. 3, and p. 283), included species.
Typified by *Mastodon humboldtii* Cuvier, including *Cuvieronius*, *Eubelodon*, and *Stegomastodon*.

Subfamily Characters. Large superior tusks without enamel, straight or upcurved; molars with single, double, or quadruple trefoils; ridge-crests $4\frac{1}{2}$ to $7\frac{1}{2}$; inferior molar ridge-crests *proverted*, superior ridge-crests transverse, *centroverted*, or *retroverted*. Central conules rudimentary or wanting.

Genus: CUVIERONIUS Osborn, 1923

Original reference: Amer. Mus. Novitates, No. 99, Dec. 27, 1923, p. 1 (Osborn, 1923.601).
Genotypic species *Mastodon humboldtii* Cuvier, 1806 (in Desmarest, 1818).
Compare *Mastotherium humboldtii* Fischer de Waldheim, 1814.

Generic Characters. (1) No enamel band on the superior tusks; (2) simple, rounded, outwardly and upwardly turned or straight superior tusks, no inferior tusks; (3) double trefoils typical on the superior and inferior grinding teeth, grinders broad; (4) rostrum of inferior mandible relatively abbreviate; (5) cranium elevated, facial region expanded, as in the true *Mastodon*, e.g., *Mastodon americanus;* (6) adaptations chiefly to a plains habitat, the use of the grinding teeth partly for grazing as well as for browsing purposes. (7) Superior ridge-crests (M^3) $4\frac{1}{2}$-5; inferior ridge-crests (M_3) $4\frac{1}{2}$-$5\frac{1}{2}$. (8) Single trefoils and downturned tusks in primitive species (*Cuvieronius ayorœ*, *C. postremus*). As observed by Osborn (figured by Cabrera, 1929, pp. 97–112): (9) Superior ridge-crests transverse, or *retroverted* internally (*Cuv. platensis, C. superbus);* inferior ridge-crests *proverted* internally (*Cuv. platensis, C. superbus*); (10) superior and inferior crowns either plane or curved on external side (*Cuv. platensis*). As observed by Osborn: (11) *Stegomastodon* related to *Cuvieronius* by *internal proversion* of ridge-crests (Figs. 578, 579) in the inferior molars (*Stegomastodon texanus, S. arizonæ, Cuvieronius platensis);* in the superior molars (Fig. 580), transverse *internal centroversion* (*Stegomastodon aftonia*), *internal retroversion* (*Cuvieronius platensis*).

As successively described by Cuvier (1806), Gervais (1855), Ameghino (1889), Nordenskiöld (1903), and Boule (1920), the characters of the genotypic species *Mastodon humboldtii* are now thoroughly established. The genus *Cuvieronius* as defined in the present Memoir embraces the following South American species, so far as they are known, presenting the above characters in common:

Cuvieronius humboldtii Cuvier, 1806 (in Desmarest, 1818), Chile [?Ecuador]

Cuvieronius chilensis Philippi, 1893, Chile

Cuvieronius Brasiliensis Lund (in Lesson, 1842), Brazil

Cuvieronius platensis Ameghino, 1888, Province of Buenos Aires, Argentina

Cuvieronius superbus Ameghino, 1888, Province of Buenos Aires, Argentina

Cuvieronius bonaerensis [=*superbus*] Moreno, 1888, Province of Buenos Aires, Argentina

Cuvieronius rectus Ameghino, 1889, Province of Buenos Aires, Argentina

Cuvieronius maderianus Ameghino, 1891, Buenos Aires, Argentina

Cuvieronius pirayuiensis Gez, 1915, arroyo Pirayuí, Paraguay

Cuvieronius ayorœ Spillmann, 1928-1931, near Punin, Ecuador

Cuvieronius postremus (1928-1931), Alangasi, near Quito, Ecuador

History.—The weight of Cuvier's authority has been so great that since 1806 the generic name *Mastodon* was applied by all authors to *humboldtii*, until Cope proposed (1884.2, p. 2) the ill-fated generic name *Dibelodon*, signifying two-tusker, which he based upon the four-tusker *Mastodon shepardi* of Leidy. Cope's practice of including *Mastodon andium* and *M. humboldtii* also within the genus *Dibelodon* was followed by Lull and Osborn until Osborn discovered Cope's error and proposed the generic name *Cuvieronius* (1923.601). Meanwhile all the European authors continued to use Cuvier's name *Mastodon*, including Boule in his important Memoir of 1920.

Remains of *Cuvieronius* are as abundant in the plains region of Argentina as they are rare in the Andean region to the west. Following Cuvier's description of the type specimen of *Mastodon humboldtii*, from near Concep-

[1]For name only, see Osborn, 1935.937, fig. 2; for definition, see Appendix to the present Volume I.

cion, Chile [?Ecuador], the most important contributions are those of Burmeister (1879–1889), of Ameghino (1888, 1889, 1891) in proposing a series of new species, and the single contribution of Philippi (1893), naming *Mastodon chilensis* from a type jaw found in the same state as that of Cuvier's type of *M. humboldtii*. Boule (1920) erroneously regards *Mastodon chilensis* as a local race of *M. andium:* the abbreviation of the jaw relates it rather to *Cuvieronius humboldtii*.

By far the most valuable morphological description of *M. humboldtii* is the recent one by Boule (1920) in which the profound distinctions between the cranium of *M. humboldtii* and that of *M. andium* are clearly brought out, as shown in the illustrations reproduced from Boule's Memoir (Figs. 495–497). Referring to previous comparisons and contrasts between *Cuvieronius humboldtii* and *Cordillerion andium*, and combining the valuable observations of Boule with those of Nordenskiöld, we may again enumerate the chief characteristics and contrasts of *Cuvieronius* as distinguished from *Cordillerion:*

Cuvieronius

(1) Animals more progressive, more elephantine, of larger size.

(2) Facial region of cranium prominent, expanded, with air-cell chambers, as in *Mastodon* and *Elephas*.

(3) Tusks relatively large, rounded, upturned or straight, with reduced or invisible enamel band.

(4) Grinders larger, with double trefoils; intermediate grinders more progressive, with rudimentary tetartoloph. Third grinders, M^3-M_3, tetralophodont to pentalophodont. Grinders broader and rounder. Trefoils partly single in *Cuv. platensis* Amegh., *Cuv. rectus* Amegh., *Cuv. postremus* Spillm.

(5) Mandibular symphysis shorter, more deflected downwards.

(6) Fossil remains found chiefly in the pampas of Buenos Aires and in Brazil; more rarely in Chile and the Andean region to the north near Quito, Ecuador.

(7) Central conules inconspicuous or absent.

Cordillerion

(1) Animals less progressive, of smaller size, more primitive in cranial, dental, and limb structure.

(2) Cranium more depressed; air-cell cavities less expanded, as in *Trilophodon*.

(3) Tusks relatively longer and more slender, spirally formed, with broad enamel band.

(4) Grinders smaller, with single trefoils, brachyodont. Third grinders M^3-M_3, narrow, tetralophodont+. Grinders more elongate.

(5) Mandibular symphysis longer, less deflected downwards; form of symphysis varying with sex; tusks more slender in females.

(6) Fossil remains found chiefly in the high plateaus of the Cordilleras; more rarely in the plains and pampean region to the southeast.

(7) Central conules more or less conspicuous.

Cuvieronius humboldtii, Genotype and Collective Species up to the Year 1888

Genotypic History.—Up to Ameghino's revision of 1888, Cuvier's '*Mastodon' humboldtii* was treated by all authors as a 'collective species' embracing all Notorostrines with *double* trefoils. Closer recent analysis shows that Cuvier's imperfect type from Chile[1] (Fig. 537) and paratype from Bolivia (Figs. 538, 559) are much more primitive in the structure of the ridge-crests, especially in M_3, than the corresponding parts in the species successively named *Mastodon platensis* Amegh. (1888), *M. superbus* Amegh. (1888), *M. bonaerensis* Mor. (1888), *M. maderianus* Amegh. (1891), all based on superior tusks. The M^3 referred to *M. rectus* by Ameghino in 1889, however, is much more primitive than the *M. humboldtii* type.

Pending monographic revision, therefore, *Mastodon humboldtii* from the west coast may be regarded as a relatively more primitive molar stage than the two east coast species widely prevailing in Argentina, namely: *M. platensis* and *M. superbus*.

Cuvieronius humboldtii Cuvier, 1806 (in Desmarest, 1818)

Figures 80, 537–539, 559

Pleistocene. Near Concepcion, Chile.[1] Syn.: *Mastodonte humboldien* Cuvier, 1806; *Mastodon humboldtii* Desmarest, 1818; *Mastodon humboldii* Cuvier, 1824; *Dibelodon humboldtii* Cope, 1884.

We are unable to locate any passage in von Humboldt's "Vues des Cordilières" of 1810-1813, or in his other available writings, in which he refers to the locality[1] where he discovered the type of the species subsequently named after him by Cuvier and Desmarest.

Cuvier's description of this classic species in 1806 as "la plus petite, *Mastodonte humboldien,*" immediately follows on the same page (1806.3, p. 413) that of "*Mastodonte des Cordilières*" [=*Cordillerion andium*]. Cuvier's type (1806.3, Pl. 67 [II], fig. 5) as confirmed by de Blainville (1839–1864, p. 249) is a three crested first

[1]Cabrera (1929, p. 66) points out that von Humboldt did not travel in Chile, and that it is possible this molar fragment came from a town of the same name, Concepcion, in Ecuador, where the distinguished voyager traveled extensively. Both Cuvier's primitive *type* (Fig. 537) and the *paratype* from Bolivia (Figs. 538, 559) should be compared, therefore, with the corresponding ridge-crests in *Cuvieronius ayora* Spillm. and *C. postremus* Spillm. from Ecuador.

CUVIERONIUS HUMBOLDTII: TYPE (LEFT) FROM CONCEPCION, CHILE [?ECUADOR]; PARATYPE (RIGHT) FROM PROVINCE OF CHIQUITOS, BOLIVIA

Fig. 5.

Fig. 537. Type of "la plus petite, *Mastodonte humboldien*," as first designated by Cuvier in 1806.3, p. 413, and first figured by him in Pl. 67 [II], fig. 5; it was brought to Cuvier by Alexander von Humboldt, found near Concepcion, Chile [?Ecuador]. A first or second molar; regarded by Falconer (1868, I, p. 101) as a deciduous molar.

As fully described above, this is universally accepted as Cuvier's type specimen of *Mastodon humboldtii* [=*Cuvieronius humboldtii* of the present Memoir]. One-half natural size.

The two posterior ridge-crests and talonid in Cuvier's type (Fig. 537) from Chile [?Ecuador] and in the paratype (Figs. 538, 559) from Bolivia are much less progressive than the corresponding ridge-crests of M_3 in *Cuvieronius platensis* or *C. superbus* of Argentina.

Fig. 12.

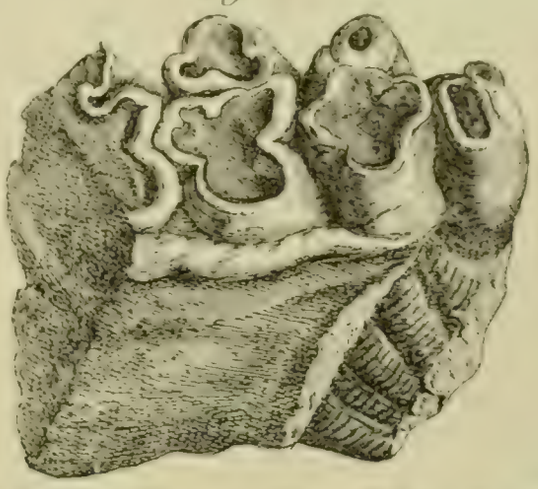


Fig. 538. Osborn's paratype of *Mastodon humboldtii* Cuv. After Cuvier 1806.3, Pl. 67 [II], fig. 12. About one-half natural size. The original is probably in the Muséum d'Histoire Naturelle, Paris, but could not be located for the writer during his visit of 1921. The specimen is a third left inferior molar, l.M_3, of which one or two anterior crests have been broken off. Compare Gervais' figure (1855) of *M. humboldtii* [=*Cuvieronius (?)platensis*], figure 504 of the present Memoir. From near Santa Cruz de la Sierra, Province of Chiquitos, Bolivia.

(Osborn, 1931) Observe that these inferior type (Fig. 537) and paratype (Fig. 538) molars of Cuvier's original description of 1806 agree in the presence of large infero-external and small infero-internal trefoils and cones, thoroughly confirming Cuvier's definition of *Mastodonte humboldien*.

(Osborn, 1933) The two posterior ridge-crests and biconed talonid in l.M_3, agree closely in evolution with the corresponding parts in l.M^3 of *Cuvieronius platensis* (cf. Fig. 559).

or second molar reproduced in facsimile in our figure 537. This is important to note, because the original of this type appears to be misplaced. The designation of the type is as follows:

"Et la plus petite, *Mastodonte humboldien*," Cuvier, 1806, p. 413 = *Mastodon humboldtii* Cuvier (in Desmarest, 1818, p. 447), also *Mastodon humboldii*, Cuvier, 1824, Vol. V, Pt. 2, p. 527. "Sur Différentes Dents du Genre des Mastodontes." Ann. Mus. d'Hist. Nat., 1806, VIII, pp. 411–413.

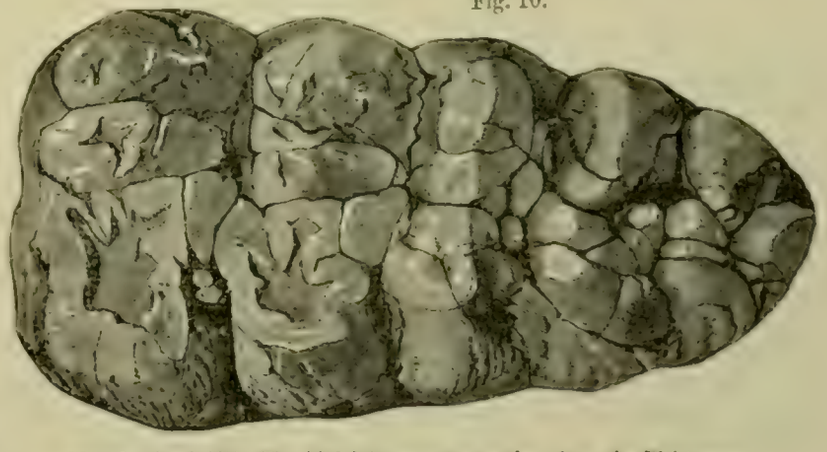
TYPE DESCRIPTION.—(Cuvier, 1806.3, p. 412): . . . "M. *de Humbold* est encore celui qui les a découvertes. Je lui en dois une qu'il a rapportée de la *Conception* du *Chili;* elle est fort usée, mais bien conservée, teinte en noir, longue de 0,08, et large de 0,06. Voyez pl. II [67], fig. 5." TYPE.—A first or second molar. Cuvier, 1806.3, Pl. 67 [II], fig. 5; confirmed by de Blainville (1839–1864, p. 249). TYPE LOCALITY.—Near Concepcion, Chile [?Ecuador].

Cuvier's designation of the type grinders, "Et la plus petite, *Mastodonte humboldien*," 1806, p. 413, renders it probable that this small tooth was the first which came into his hands, or else he selected it out of courtesy to von Humboldt, because the paratype specimen (Pl. 67 [II], fig. 12), an inferior molar (Fig. 538 of the present Memoir), is more characteristic of this genus. The description by Cuvier of the latter (*op. cit.*, p. 412) is as follows: "C'est encore à cette espèce que je rapporte la dent de la même province de *Chiquitos*, dont M. Alonzo m'a envoyé le dessin (Pl. II, fig. 12). Comme elle n'est pas entière en avant, on ne peut assigner sa place; mais je juge à son talon qu'elle est ou la moyenne ou la postérieure d'en haut."[1] See figures 537 and 538 above.

[1]Osborn's paratype of Cuvier's *Mastodonte humboldien* is from near Santa Cruz de la Sierra, between Chichas and Tarija, Bolivia, 15° so. lat., whereas the *type* is from near Concepcion, Chile [?Ecuador].

(Falconer, 1868, Vol. I, p. 101): "The third deciduous molar is well represented by Cuvier (tab. ii. fig. 5). The original, brought by Humboldt from Chili, is the specimen upon which the illustrious anatomist founded his *M. Humboldtii*. It is an oblong and nearly rectangular tooth, presenting the same square proportions

Fig. 10.



Mastodon humboldti.—The third left upper true molar; from the Pleistocene of Buenos Ayres. ⅔. The lower border of the figure is the inner border of the specimen.

Fig. 539. Third left superior molar, l.M^3, of *Cuvieronius humboldtii*, two-thirds natural size. After Lydekker, 1886.1, p. 43, fig. 10. Brit. Mus. 19952b. Observe 5¼ ridge-crests.

as in *M. ohioticus*, and having the crown divided into three ridges, which are far advanced in wear, and without either a front or a back talon. It measures 3.15 inches in length by 2.35 inches in width. As yet there is no evidence of a premolar in the upper jaw."

CRANIAL AND DENTAL CORRELATION

CUVIERONIUS HUMBOLDTII, TUSKS AND GRINDERS.—Gervais, 1855) describes the third superior and inferior molars of *Mastodon humboldtii* as somewhat larger and relatively broader than those of *M. andium*. This corresponds with the breadth-length measurements and indices of M_3 given above (p. 545), as derived by careful calculation from his plates, namely:

M_3 *Cordillerion andium:* breadth-length index, 40
M_3 *Cuvieronius humboldtii*,[1] breadth-length index, 47

The third superior molars of *Cuvieronius humboldtii* [=(?)*platensis*, Fig. 540, No. 9] exhibit five plus ridge-crests, whereas the third superior molars of *Cordillerion andium* (Fig. 540, No. 3) exhibit only four ridge-crests and a large talon. In both genera and species the third superior molars are broader anteriorly and suddenly contract posteriorly; in *C. andium* the elongate triangular crown of M^3 is readily distinguished from the oblong crown of M_3.

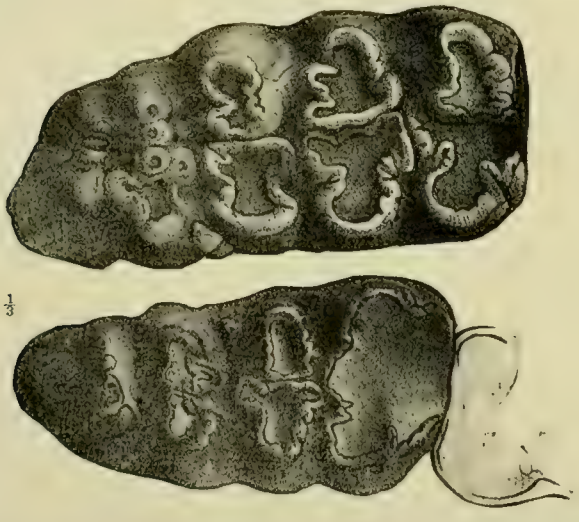


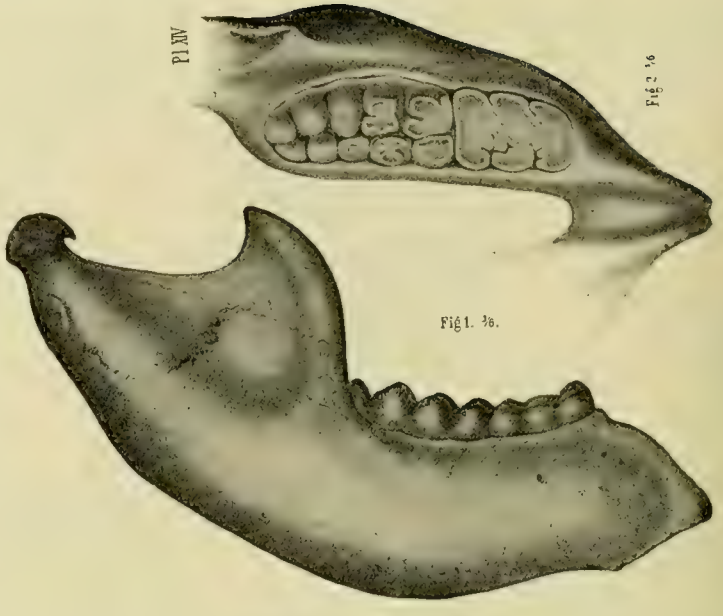
Fig. 540. Right third superior molars of *Cuvieronius* (upper) and of *Cordillerion* (lower), after Gervais, 1855, Pl. v, figs. 9 and 3, one-third natural size.
(Lower) *Mastodon andium:* "3. Sixième molaire supérieure [of Tarija, Bolivia]." Single trefoils, 4½ ridge-crests. [=*Cordillerion andium*.]
(Upper) *Mastodon humboldtii:* "9. Sixième molaire supérieure (de Buenos-Ayres)." Double trefoils, 5+ridge-crests. [=*Cuvieronius* (?)*platensis*.]

GRINDING TEETH OF CUVIERONIUS.—The contrast between the grinding teeth of the two genera has been clearly brought out in a series of comparative figures given above in the characterization of the genus *Cordillerion* and in the descriptions of the species of that genus.

Attention is called especially to the admirable figures of Gervais (1885, Pl. v, reproduced above in our Fig. 504) and to the present figure (Fig. 540) showing an intimate comparison, to the same scale, of the third superior grinding teeth.

The profound structure of the grinding teeth of *Cuvieronius* is quite as distinct generically from that of *Cordillerion* as is the structure of the tusks and of the cranium.

[1]Referred in the present Memoir to *Cuvieronius* (?)*platensis*.



CUVIERONIUS SUPERBUS REF.

Fig. 541. *Mastodon humboldtii* ref., after Burmeister, 1866, Lám. XIV, figs. 1 and 2, one-sixth natural size. This specimen is in the "Museo público de Buenos Aires," locality unrecorded. Referred by Cabrera (1929.1, pp. 120, 121) to *Cuvieronius superbus* (see Appendix to present Volume I).

W. D. MATTHEW, SEPTEMBER, 1920: BRITISH MUSEUM.—A fair skull of *M.* [=*Cuvieronius*] *humboldtii* in the British Museum has the top of the cranium restored; it is larger than the Paris skulls of this species, but otherwise exhibits similar characters; the skull very nearly parallels that of *Mastodon americanus* in form and in the abbreviation of the symphysis, but the superior outline of the symphysis is straight instead of convex. The upper tusks lack the horizontal form and the spiral twist of *M.* [=*Cordillerion*] *andium;* they are wide apart at the base and tend to curve inward a little more than upward. Both the tusks and symphysis, as well as the skull, parallel those of *M. americanus*.

Osborn, 1927: The generic phylum *Cuvieronius* may be regarded, therefore, as a very ancient one; its ancestral stages should be found to exhibit single trefoils on the molar teeth and a more or less vestigial lateral band of enamel on the incisive tusks, whereas the skull would gradually lead back to a primitive form not very dissimilar to that of *Cordillerion*.

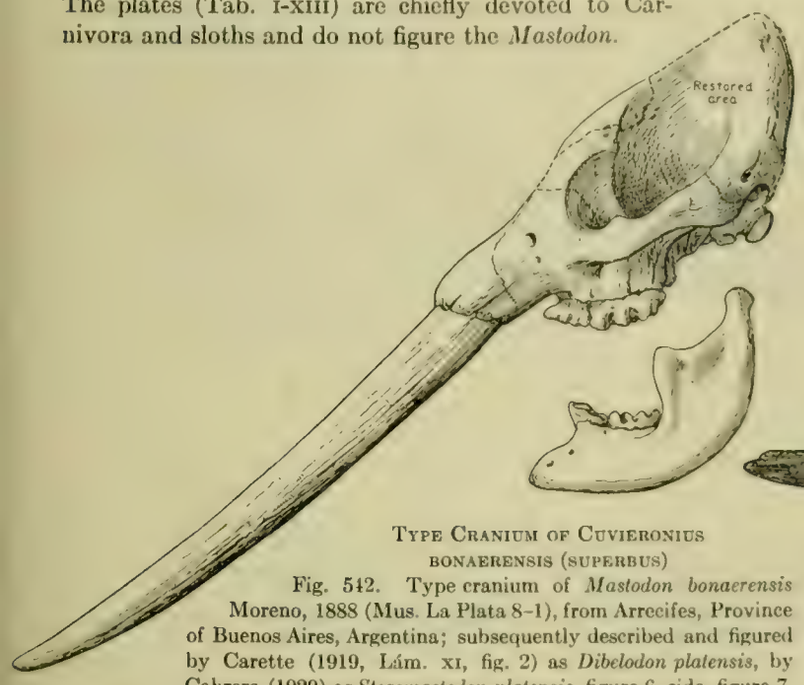
Cuvieronius brasiliensis Lund (in Lesson, 1842)

From a limestone cave in the valley of the Velhas River, near the central part of the Province of Minas Geraes, Brazil (see Lund, 1839, pp. 30 and 133). An admirable abstract of Lund's researches in the caves of Central Brazil, "mostly situated in a district near the head waters of the San Francisco river in the Province of Minas Geraes," is to be found in Wallace's "The Geographical Distribution of Animals," 1876, Vol. I, pp. 143–146.

This animal, as described by Lund in 1839, pp. 117, 129, 130, 133, and 136, was first listed as *Mastodon* sp. on page 133; in this description he compared the animal with *Mastodon andium* and *M. Humboldtii* of Cuvier, but did not figure it; judging by his description, this mastodont is more closely related to *Cuvieronius humboldtii*.

Lesson (1842, p. 157) attributed the specific name *Mastodon Brasiliensis* to Lund. Since we are unable to find Lund's designa-

tion of this species, the name may be written as above, namely, *Cuvieronius brasiliensis* Lund (in Lesson, 1842). The fossil cave fauna, as indicated in Lund's Memoir of 1839, Table II, pp. 133–135, as from the Province of Minas, "Rio das Velhas," contains one species of anteater, several species of armadillo and of glyptodont, four species of the giant sloth, chiefly *Megalonyx*, four species of peccary, one tapir, besides the *Mastodon brasiliensis;* artiodactyls attributed to *Cervus, Antilope, Camelus, Leptotherium;* ten species of Carnivora, two of *Didelphis*, eight genera of rodents, and one monkey (*Protopithecus*). Naturally many of the references, such as *Antilope, Camelus*, and *Hyæna*, are out of date. The plates (Tab. I-XIII) are chiefly devoted to Carnivora and sloths and do not figure the *Mastodon*.



TYPE CRANIUM OF CUVIERONIUS BONAERENSIS (SUPERBUS)

Fig. 542. Type cranium of *Mastodon bonaerensis* Moreno, 1888 (Mus. La Plata 8–1), from Arrecifes, Province of Buenos Aires, Argentina; subsequently described and figured by Carette (1919, Lám. XI, fig. 2) as *Dibelodon platensis*, by Cabrera (1929) as *Stegomastodon platensis*, figure 6, side, figure 7, front, figure 10*a*, mandible, side, figure 11*a*, mandible, top, as reproduced in figures 532 and 562 of the present Memoir.

Cuvieronius bonaerensis Moreno, 1888

Figures 532, 542, 562, and 564

From Arrecifes, Province of Buenos Aires, Republic of Argentina; Lower Pampean. Said to be synonymous with *Mastodon platensis* Amegh., 1888. Pleistocene.

Cranium, tusks, and jaws named *Mastodon bonaerensis* by Moreno (Fig. 542) in 1888; figured as *Dibelodon platensis* by Carette (Fig. 532) in 1919; fully described and figured as *Stegomastodon platensis* by Cabrera (Fig. 562) in 1929; regarded by Osborn (1933) as related to *Cuvieronius superbus*, namely, *Cuvieronius bonaerensis* (*superbus*).

Mastodon bonaerensis Moreno, 1888. "Informe Preliminar," Bol. Mus. La Plata, Vol. I, p. 18. TYPE.—Cranium (Mus. La Plata No. 8–1). HORIZON AND LOCALITY.—From Arrecifes, Province of Buenos Aires, Republic of Argentina. Pleistocene. TYPE FIGURE.—Not figured by Moreno, but figured (Fig. 532) by Eduardo Carette, 1919, Pl. XI, fig. 2, as *D. platensis*. Refigured (Fig. 542) in the present Memoir from pen sketch kindly furnished by Doctor Cabrera of the La Plata Museum; referred to *Stegomastodon platensis* in Cabrera's Memoir of 1929, figs. 6 and 7 (cf. Fig. 562B of present Memoir).

TYPE DESCRIPTION.—(Moreno, 1888, pp. 17 and 18): "8° Cráneo con los dos grandes colmillos que miden un largo total de 1 metro 80 centímetros, mandibula inferior, parte de la columna vertebral, costillas, un brazo, la pelvis, un fémur, tibia y peroné, y varios huesos de las extremidades de un gran mastodonte, que considero como una nueva especie y que he nombrado *Mastodon bonaerensis*."

Osborn, 1933: The ridge-crests resemble those of *Cuvieronius superbus* (cf. Fig. 562).

Cuvieronius platensis[1] Ameghino, 1888

Figures 488, 489, 498, 531, 540, 543, 553, 558–560, 563, 564, 579, 580

Lower Pampean formation, San Nicolás de los Arroyos, Province of Buenos Aires, Argentina. Pleistocene.

Syn. (*fide* Cabrera): *Mastodon bonaerensis* Mor., 1888, *M. rectus* Amegh., 1889, *M. maderianus* Amegh., 1891.

HISTORY.—The type of this species is a rounded tusk of large size; it is similar to that characteristic of *Cuvieronius humboldtii*.

Defensa de *Mastodon platensis*, AMEGH. $^{1}/_{15}$ del tamaño natural

TYPE OF CUVIERONIUS PLATENSIS

Fig. 543. Type superior tusk of *Mastodon platensis* Ameghino, 1888. After Ameghino, 1889, p. 641, one-fifteenth natural size. Original in Museo Nacional de La Plata, No. 8–63. [=*Cuvieronius platensis* of the present Memoir.]

The specific name may be retained pending further research. Philippi observes (1893) that *Mastodon platensis* is distinguished by long, thin, almost straight incisive tusks, greatly inferior in size to those of other species.

Mastodon platensis Ameghino. Rápidas Diagnosis, 1888, p. 7. TYPE.—Superior tusk. Original in Museo Nacional de La Plata, 8–63. HORIZON AND LOCALITY.—Lower pampean formation, San Nicolás de los Arroyos, Province of Buenos Aires, Argentina. TYPE FIGURE.—Ameghino, 1889, p. 641 (text figure); also supplementary description.

TYPE DESCRIPTION.—(Ameghino, 1888, p. 7): "Mamelones internos de las muelas superiores y esternos de las inferiores, mas anchos, y gastados en forma de hoja de trébol.—Defensas no muy gruesas, rectas ó casi rectas y sin banda longitudinal de esmalte, ni vestigios de espiral.—Talla un poco superior á la de *Mastodon andium* y algo menor que la de *Mastodon Humboldtii*.—Defensas hasta de dos metros de largo y 44 centímetros de circunferencia en la base.—Muela sesta superior de 175 mm. de largo y 8 ctm. de ancho, compuesta de cuatro colinas transversales y un callo basal posterior.—Procedencia: pampeano inferior de la provincia de Buenos Aires."

BOULE, 1920, p. 68.—"Les figures qu'il en a données portent à penser que *M. platensis* et *M. superbus* sont de simples variétés

[1]For distinctions between *Cuvieronius platensis* and *C. superbus*, see Appendix to the present Volume I.

de *M. Humboldti*, lequel est caractérisé par la forme courbe de ses défenses et l'absence de bande d'émail." Nevertheless Boule in his synopsis (*op. cit.*, p. 67) places *Mastodon platensis* in the same Division I with *M. andium*, namely: "I. Molaires dont l'usure moyenne des collines produit l'aspect d'un seul trèfle. . . . *b.* Défenses fines, presque droites, sans bande d'émail. . . . *M. platensis*. Prov. de Buenos-Aires."

Cuvieronius superbus[1] Ameghino, 1888

Figures 485, 492, 498, 502, 544, 556, 561, 562, 563, 565, 566, 576

Probably the superior Pampean, Pergamino, Province of Buenos Aires, Argentina. Pleistocene. Osborn, 1933: Compare with *Cuvieronius bonaerensis*.

History.—As shown in the diagram (Fig. 493) Ameghino distinguished the species by its gigantic size, exceeding that characteristic of *Cuvieronius humboldtii*, and by the very large size of the tusks, as shown in figure 544. Boule (1920) regards the species *Mastodon superbus* as derived from *M. platensis*, which in another branch gives off *M. humboldtii;* he also regards (*op. cit.*, p. 68) *M. superbus* as possessing, like *M. humboldtii*, double trefoils and lacking the enamel band; he describes the molars and incisive tusks as follows: "II. Molaires dont l'usure moyenne des collines produit l'aspect d'un double trèfle; pas de bande d'émail: . . . *b.* Défenses moins arquées, avec un maximum de diamètre vers le milieu. . *M. superbus*. Santa-Fé." Philippi (1893) observes that whereas *M. humboldtii* is distinguished by very thick and very strongly curved incisive tusks, *M. superbus* is characterized by tusks less thick, straight in the proximal portion, but in the distal half strongly bent. Ameghino regarded *M. platensis* as an ancestral form of both *M. superbus* and *M. humboldtii*.

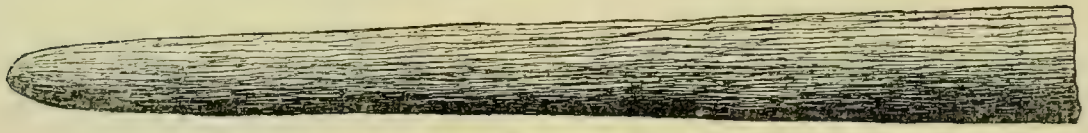
Mastodon superbus Ameghino, 1888. Rápidas Diagnosis, p. 7. Type.—Superior tusks and mandible of an old individual. Original in the Museo Nacional de La Plata, 8–8. Horizon and Locality.—Probably the superior Pampean, Pergamino, Province of Buenos Aires, Argentina. Type Figure.—Ameghino, 1889, p. 647 (text figure), and supplementary description; also Cabrera (1929), in Sec. II, 6, of this chapter.

Type Description.—(Ameghino, 1888, p. 7): "Colinas transversales de las muelas gastadas en forma de doble hoja de trébol como en *Mastodon Humboldtii*.—Talla gigantesca, mayor que la de *Mastodon Humboldtii*, pero menos robusto.—Defensas muy largas, pero proporcionalmente delgadas, con curva poco sensible en la mayor parte de su largo, pero muy pronunciada en su cuarto anterior y con su grueso máximo hácia la mitad; carecen de todo vestigio de curva en espiral, y de banda de esmalte, alcanzando un tamaño de 2 m. 40 de largo, por 53 ctm. de circunferencia en la base.—Largo de la última muela superior, 24 ctm.—Largo de la última muela inferior, 27 ctm.—Fémur de 1 m. 10 de largo, pero relativamente delgado.—Procedencia: pampeano lacustre de la provincia de Buenos Aires."

Defensa del *Mastodon superbus*, Amegh, $^1/_{20}$ del tamaño natural

Type of Cuvieronius superbus

Fig. 544. Type superior tusk of *Mastodon superbus* Ameghino, 1888. After Ameghino, 1889, p. 647, one-twentieth natural size. Original in the Museo Nacional de La Plata, 8–8. [=*Cuvieronius superbus* of the present Memoir.]



Defensa de *Mastodon rectus*, Amegh. $^1/_{13}$ del tamaño natural

Type of Cuvieronius rectus

Fig. 545. Type superior(?) tusk of *Mastodon rectus* Ameghino, 1889, p. 643, one-thirteenth natural size. Original in the Museo Nacional de La Plata, 8–38. [=*Cuvieronius rectus* of the present Memoir.]

Cuvieronius rectus Ameghino, 1889

Figures 490, 531, 545, 546, and 558

From the Ensenada, near La Plata, Argentina. (Cabrera, 1929, p. 99): "Dos defensas de un macho muy viejo, de La Ensenada, cerca de La Plata; tipo de *M. rectus* Ameghino (n° 8–38)." Compare Carette, 1919, Lám. xi, fig. 3 (Fig. 531 of the present Memoir), also Cabrera, 1929, p. 112.

Distinguished by Ameghino as a species of large size related to *Mastodon humboldtii*, with straight tusks attaining a maximum length of 2 m. 10 cm. Philippi (1893) observes that this species is distinguished by straight, very thick incisive tusks.

Boule, 1920, p. 67.—Boule in his synopsis considers *Mastodon rectus* as belonging to species with single trefoils and describes the molars and tusks as follows: "I. Molaires dont l'usure moyenne des collines produit l'aspect d'un seul trèfle. . . . *c.* Défenses plus massives, sans bande d'émail, droites ou presque droites. *M. rectus*. La Plata, Buenos-Aires."

On the next page he remarks: "La dénomination *M. rectus* a pu être appliquée à une anomalie ou à un échantillon mal conservé de *M. andium*."

[1]See footnote on page 579.

Ameghino's type description is in general as follows:

Mastodon rectus Ameghino, 1889. "Contribucion al Conocimiento de los Mamiferos Fósiles de la República Argentina." Actas Acad. Nac. Cien. Córdoba, Tome VI, 1889, p. 643. TYPE.—Superior tusk. Original in the Museo Nacional de la Plata, 8–38. HORIZON AND LOCALITY.—"Todos los restos que conozco de esta especie proceden de las excavaciones del Puerto de La Plata en la Ensenada, y de las del puerto Madero en Buenos Aires, con excepcion de un par de defensas casi intactas encontradas al cavar un pozo en el mismo municipio de Buenos Aires, en la casa del comandante Espina. . . . Piso ensenadense de la formacion pampeana." TYPE FIGURE.—Ameghino, 1889, p. 643 (text figure).

REFERRED MOLAR OF CUVIERONIUS RECTUS. PRIMITIVE. COMPARE CUV. POSTREMUS

Inferior Pampean

Fig. 546. *Mastodon rectus* ref. from near the Atlantic coast, Province of Buenos Aires, Argentina (*fide* Ameghino, 1889, p. 920). After Ameghino, 1889, Lám. XCVIII, fig. 1. *Stegomastodon superbus* (*fide* Cabrera, 1929, p. 116). Compare *Cuvieronius postremus* (Figs. 530, 550, 552), single trefoils.

A third left superior molar, l.M^3, 204e×102 mm., reduced to one-half natural size, tetralophodont+ (4½ ridge-crests). Supero-internal trefoils larger, more worn. Supero-external trefoils much smaller, present in protoloph, reduced in metaloph, very small in tritoloph. Tetartoloph narrow. Pentaloph rudimentary.

(Ameghino, 1889, p. 920): "El mamelon externo de cada colina, es comprimido de adelante hácia atrás, y muy estendido en sentido transversal, de cúspide elevada y que dá por el desgastamiento una figura transversal muy angosta y elevada, mas ó menos del mismo ancho en todo su largo. Los mamelones internos son al contrario angostos sobre el borde interno, y anchos sobre el externo, en donde presenta tubérculos accesorios que dan con el desgastamiento á la superficie de trituracion, la forma de hoja de trebol."

TYPE DESCRIPTION.—(Ameghino, 1889, p. 643): "Esta especie es de tamaño jigantesto, comparable al del *Mastodon Humboldti*, del que se distingue por las defensas completamente rectas, aunque en algunos individuos presentan una pequeña curva, apenas acentuada en la extremidad anterior. Las defensas de esta especie, de los individuos adultos masculinos, tienen de 1^{m}80 á 2^{m}10 de largo, por 42 á 50 centímetros de circunferencia en la base, que es comprimida lateralmente, disminuyendo poco de grueso hasta que terminan en punta gruesa y roma, que á menudo presenta una superficie lisa gastada por el frotamiento del diente. Estas defensas carecen completamente de la banda de esmalte que distingue las de los *Mastodon andium* y *Mastodon argentinus*, y no presentan vestigios de la curva en espiral que distingue la primera de las mencionadas especies, como lo demuestra el grabado adjunto que representa una defensa de esta especie. El fémur de la misma especie tiene 1 metro de largo, y las muelas por los pocos fragmentos que poseo parecen estar construidas sobre el mismo tipo que las del *Mastodon andium*."

GRINDING TEETH.—Ameghino (1889, Pl. XCVIII) gives a natural size figure of a large broad grinding tooth (Fig. 546) with 4½ ridge-crests, which he designates as follows in his explanation of the plate: "1. *Mastodon rectus* Amegh. Última muela superior del lado izquierdo, vista por la superficie masticatoria."

Boule (1920) in describing this *referred* specimen observed: "I. Molaires dont l'usure moyenne des collines produit l'aspect d'un seul trèfle." The infero-internal trefoils are certainly rudimentary.

Osborn, 1931: This relatively primitive superior molar from near the Atlantic coast, Province of Buenos Aires, Argentina, should be compared with the relatively primitive inferior molars from Ecuador (Figs. 534 and 535, of the present Memoir), referred to *Cuvieronius ayorœ*.

Cuvieronius maderianus Ameghino, 1891

"En las escavaciones del Puerto Madero en Buenos Aires," Argentina.

So far as can be found, this type was not figured; consequently we rest its characters upon the author's type description. It was described as of gigantic size, equaling that of *Mastodon humboldtii*. The type is a pair of tusks belonging to two complete adult individuals, and measuring 2 m. 5 cm.

Mastodon maderianus Ameghino, 1891. "Mamíferos y aves fósiles argentinas.—Especies nuevas, adiciones y correcciones." Revista Argentina de Hist. Nat., Tome I, p. 243. TYPE.—Pair of tusks. HORIZON AND LOCALITY.— . . . "en las escavaciones del Puerto Madero en Buenos Aires. Piso ensenadense de la formacion pampeana (plioceno inferior)." TYPE FIGURE.—The present author is unable to locate a figure.

TYPE DESCRIPTION.—(Ameghino, 1891, p. 243): "Talla gigantesca, comparable á la de *Mastodon Humboldtii*, pero de defensas casi derechas, parecidas á las de *Mastodon platensis* Amegh., aunque de curva todavia menos acentuada. Se distinguen además fácilmente de las de esta especie por su tamaño mayor, y por poseer una ancha faja de esmalte lateral que la recorre en todo su largo, limitada solo á su parte anterior en los individuos muy viejos. Longitud de las defensas de individuos completamente adultos, en linea recta, 1^m 90 á 2^{m}5. Circunferencia en su parte más gruesa 54 centímetros. Ancho de la faja de esmalte, de 4 á 6 centímetros. Se han descubierto los restos de esta especie en abundancia, en las escavaciones del Puerto Madero en Buenos Aires. Piso ensenadense de la formacion pampeana (plioceno inferior)."

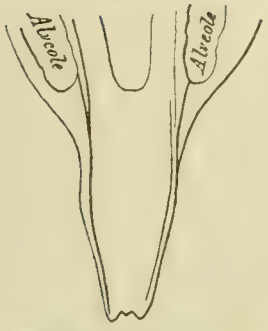
Cuvieronius chilensis Philippi, 1893

Figure 547

Near Lake Tagua-Tagua, Chile (*fide* Boule, 1920).

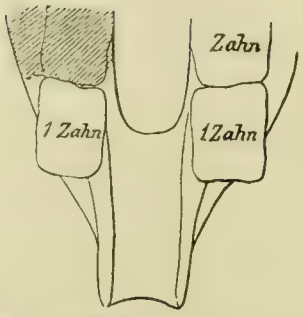
Philippi's type figure, "Figur 4," reproduced below (Fig. 547), represents a short, massive symphysis like that of *Cuvieronius*, which Philippi himself contrasts with the elongate rostrum, "Figur 1" and "Figur 3," of *Mastodon andium* of Tarija and Chile

Figur 1.



Mastodon andium, nach d'Orbigny von Tarija.

Figur 2.

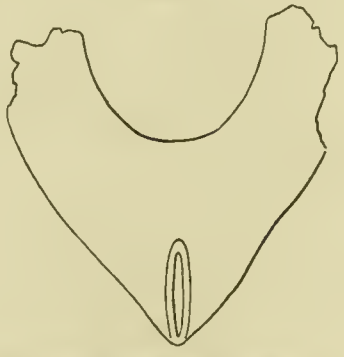


Mastodon bolivianus. 1/8 nat. Gr.

Figur 3.

Mastodon andium, nach Gay von Chile.

Figur 4.



Mastodon chilense Ph. 1/8 nat. Gr. Unterseite des Kinns.

Fig. 547. Types of Cuvieronius chilensis and Cordillerion bolivianus compared with Mastodon [=Cordillerion] andium

"Figur 2." Type of *Mastodon bolivianus* Philippi, 1893, p. 89, fig. 2, one-eighth natural size. From Ulloma, Bolivia.

"Figur 4." Type of *Mastodon chilensis* Philippi, 1893, p. 89, fig. 4, one-eighth natural size. From near Lake Tagua-Tagua, Chile (*fide* Boule, 1920).

and with his own *Mastodon bolivianus;* consequently Osborn relates *Mastodon chilensis* Philippi to the genus *Cuvieronius*, differing widely from Boule (1920, p. 68), who remarks: . . . "paraît n'être qu'une race locale de *M. andium.*" In this connection it is important to note that Cuvier's type of *M. humboldtii* is recorded from near Concepcion, Chile.

Philippi, after reviewing the series of species described by Ameghino, as quoted in full above, concludes (1893, p. 88): "Bei der Gelegenheit will ich erwähnen, dass ich das chilenische *Mastodon* für eine eigene Art halten muss, die ich *M. chilensis* nenne." The following is an abbreviation of his type description:

M. [*Mastodon*] *chilensis* Philippi, 1893. "Vorläufige Nachricht über fossile Säugethierknochen von Ulloma, Bolivia." Zeits. Deutsch. geol. Ges., Bd. XLV, 1893, p. 88. Type.—Lower jaw. Horizon and Locality.—Near Lake Tagua-Tagua, Chile (*fide* Boule, 1920, p. 68). Type Figure.—Philippi, *op. cit.*, 1893, p. 89, fig. 4.

Type Description.—Philippi distinguishes *Mastodon chilensis* as follows: (Philippi, 1893, p. 88): "Bei der Gelegenheit will ich erwähnen, dass ich das chilenische *Mastodon* für eine eigene Art halten muss, die ich *M. chilensis* nenne. In Gay's bekanntem Werk (Historia fisica i politica de Chile) beschreibt Gervais?, Zoologia, I, p. 137, die von Gay nach Paris gebrachten Zähne und Knochenreste unter dem Namen *M. andium*, und Ameghino citirt dies chilenische *M. andium* ohne Weiteres zu dem bolivianischen. Es ist mir unbegreiflich, wie Gervais? diesen Irrthum hat begehen können; hätte er sich die Mühe gegeben, das Kinn des chilenischen *Mastodon*, welches er l. c., t. 8, f. 1 abbildet, mit der von d'Orbigny gegebenen Abbildung des Unterkiefers (Voy. dans l'Amér. méridion.) zu vergleichen, so würde der erste Blick ihn überzeugt haben, dass beide himmelweit verschieden sind; das Kinn läuft bei *M. andium* in eine lange, löffelförmige Verlängerung aus, bei *M. chilensis* ist es sehr kurz, fast spitz. Unser Exemplar hat auf der Unterseite an der Spitze eine 7 cm lange, 10–12 mm breite, ziemlich tiefe Rinne, die jederseits von einem lippenartigen Wulst eingefasst ist. Von dieser Rinne sagt die Beschreibung nichts. In der Abbildung der Oberseite des Kinnes ziehen sich zwei erhabene Kanten, von der Spitze an divergirend, nach hinten. (S. Textfig. 3.) Die Verschiedenheit in der Gestalt ist so gross, dass man beinahe eine zweite chilenische Art annehmen könnte. Das von mir abgebildete Kinn, dessen Oberseite sehr abgeblättert ist und keine Spur der erwähnten Kanten mehr zeigt, wurde im Jahre 1877 von meinem Sohn bei Chillan nebst Beinknochen etc. ausgegraben; es waren dabei sämmtliche acht Backenzähne, von denen zwei gestohlen sind, und beide Stosszähne, die aber bis auf die Spitzen in winzige Fragmente zerfielen; die Schädelknochen waren zu Mulm zerfallen."

The characters of the *symphysis* of *M. chilensis* are displayed in the accompanying figure (Fig. 547).

Boule, 1920, p. 68.—"*Mastodon chilensis*, trouvé sur les bords du lac Tagua-Tagua au Chili et décrit par Philippi . . . , paraît n'être qu'une race locale de *M. andium.* Ses caractères distinctifs seraient surtout la brièveté relative de la gouttière symphysaire et la présence de deux saillies en forme de lèvres à la face inférieure de la symphyse. La première de ces distinctions résulte de l'interprétation d'une figure erronée de d'Orbigny . . . ; la seconde, nous l'avons montré précédemment, n'est qu'un trait individuel de certains *M. andium.*"

Cuvieronius pirayuiensis Gez, 1915

"Generalidades sobre paleontologia argentina: El *Mastodon platensis*-Amegh. de Corrientes. Corrientes, 2ª edición." 1915, p. 35.

The type description of this species was not available at the time that the present section went to press. Cabrera, 1929, p. 73, refers to this species as follows: "Con anterioridad al trabajo del doctor Carette, en 1915, se publicó en Corrientes un folleto del professor Juan W. Gez que, aun cuando de muy escaso valor científico, es preciso mencionar también aquí, por referirse al hallazgo de restos de mastodonte en el arroyo Pirayuí. En realidad se trata de una conferencia de divulgación, hecha a base de lecturas no siempre bien elegidas, e ilustrada con reproducciones de grabados de diversas obras y algunas fotografías. Lo interesante del folleto está en que lleva en la carátula el titulo *El Mastodon platensis de Corrientes* (*Mastodon pirayuiensis*), con lo que al autor, sin necesidad ni justificación ninguna, se da el gusto de añadir un nombre más."

Cuvieronius ayoræ Spillmann, 1928–1931

Figures 498, 534, 535, 548, and 549

Quebrada [canyon] of Chalang, near Punin, southeast of Riobamba, Province of Chimborazo, Ecuador. Pleistocene (*fide* Spillmann).

Tetrabelodon (*Bunolophodon*) *Ayora* Spillmann, 1928. "Tetrabelodon nov. spec. Ayora-Spillm." (unsigned, no pagination) and "El Mastodonte de Alangasi" (p. 75), in El Ecuador Comercial, Ano VI, No. 57, March, 1928. Full description by Spillmann, "Die Saugetiere Ecuadors im Wandel der Zeit," 1931, pp. 67–73, with figures (as *Bunolophodon ayorae*). TYPE—Cranium with grinding teeth, tusks, and mandible, also skeleton (see footnote, p. 532 above). Mus. Univ. Cent., Ecuador. HORIZON AND LOCALITY.—Quebrada [canyon] of Chalang, near Punin, southeast of Riobamba, Province of Chimborazo, Ecuador. Pleistocene (*fide* Spillmann). TYPE FIGURE.—*Op. cit.*, 1928, fig. 2. See also figures 548 and 549 of the present Memoir.

DESCRIPTION (UNSIGNED).—(*Op. cit.*, 1928) "El ejemplar mastodónico de Callihuaico, *Tetrabelodon nov. spec. Ayora-Spillm.*, se diferencia de los otros mastodontes de las cordilleras en que: según los estudios más recientes al respecto, los de Boule y Thévenin, 1920, se ha tenido por cierto, que todos los mastodontes de las alturas pertenecian a la clase *Andium;* siendo asi que, de los estudios de los cráneos de los mastodontes encontrados en nuestro pais (Riobamba y Callihuaico), se ha llegado a la conclusión de que éstos son de forma más desarrollada en su cráneo y dentadura."

"El *Andium*, fig. 3, tiene una cabeza casi plana, con un ángulo de inclinación de 20°. El *Ayora-Spillm.*, fig. 2, es un término medio entre estos dos extremos aceptados Boule y Thévenin, su cráneo presenta un ángulo de inclinación de 37°, que lo diferencia de sus compañeros de Bolivia, Argentina y Sur del Brasil. La dentadura *Bunolophodon Ayora-Spillm.* también difiere de la de las otras especies, por la falta de la forma treboloide en los dientes gastados; los colmillos, defensas, que en el *Andium* son redondos y de estructura en forma de espiral hacia afuera y formando dos curvas, en el *Ayora-Spillm.* son casi rectos (sin fajas de esmalte), con una sola curva, y su corte transversal es elipsoide. El descubrimiento del fósil de Alangasi viene a probar que esta clase de mastodontes existieron en una época geológica posterior a los *Andium*, en la moderna o histórica, derrumbando la creencia de que los mastodontes americanos pertenecieron a una fauna pleistocenia."

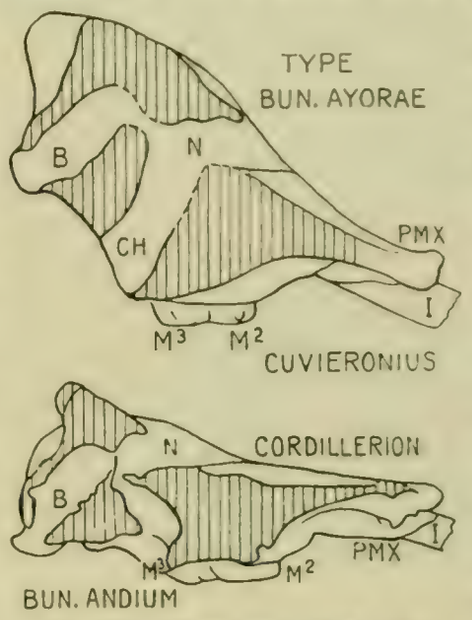


Fig. 549. CUVIERONIUS AYORÆ AND CORDILLERION ANDIUM, SECTIONS

(Upper) Type figure of cranial section of '*Bunolophodon*' *ayorx*. Compare 1928, fig. 2.

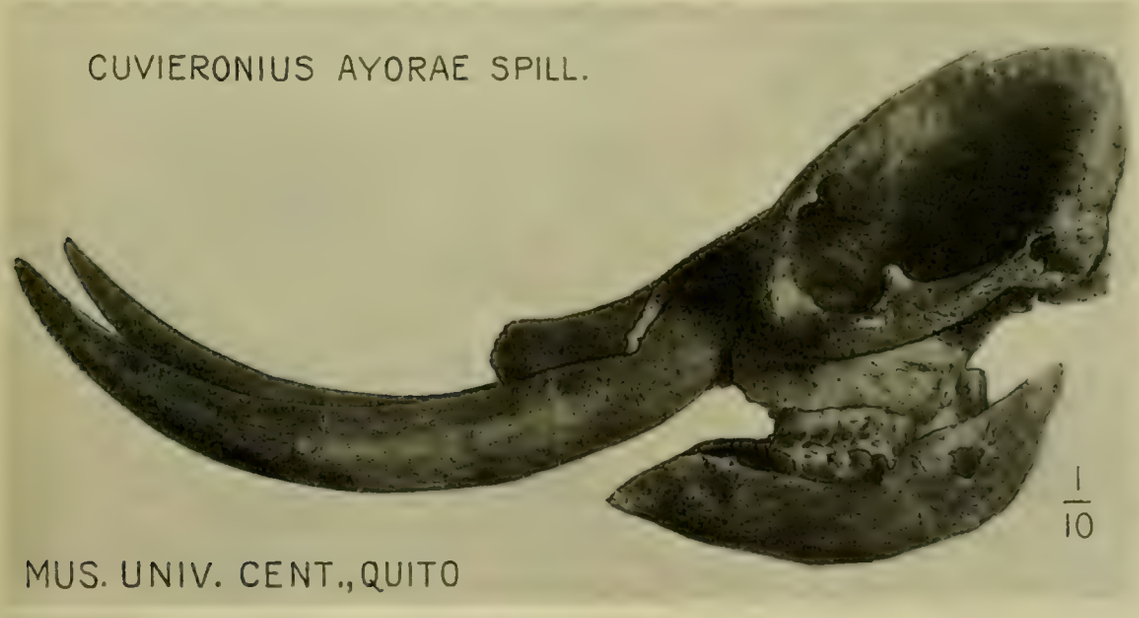
(Lower) Corresponding section of *Cordillerion andium*. Compare 1928, fig. 3.

"Mayores detalles de este valioso hallazgo los damos en otra sección del presente número."

(*Op. cit.*, unsigned, 1928, p. 75): "Del rápido estudio del cráneo, efectuado por el doctor Spillmann, este ha constatado que pertenece a la misma especie del *Bunolophodon Ayora* Spill. encontrado en Riobamba.

Según el profesor Spillmann, el cráneo de esta especie se diferencia de los *Andium* y *Humboldti*, encontrada en Bolivia, Argentina y Brasil, en que, mientras el *Bunolophodon Andium*, tiene el cóndilo oxipital en el mismo plano de las muelas y el temporal es plano; y el *Humboldti* tiene el perfil inclinado en 45° más o menos, el cráneo del *Ayora*, Spill., está en un término medio de los dos."

To the same species Doctor Spillmann refers a molar from the region between Urcuquí and Imantag in the Province of Imbaburra.



TYPE OF CUVIERONIUS AYORÆ

Fig. 548. Complete male cranium, tusks, and mandible of "*Bunolophodon ayorx* aus Chalang," in the Museum Universidad Central del Ecuador, Quito, one-tenth natural size. After photograph. Compare Spillmann, 1931, figure opposite page 68.

(Spillmann, 1931, p. 67): "Der eine, bestehend aus einem fast kompletten Schädel und diversen Extremitätenknochen, stammt aus der Quebrada von Chalang, nahe dem Indianerdorfe Punin, in der Provinz Chimborazo."

Provisionally referred to this species is a mandible with grinding teeth (F:A.M. 28293) and a left superior molar, l.M[1] (Amer. Mus. 22561), from Ecuador; the two latter specimens are in the American Museum (Figs. 534, 535); in the superior molar (Fig. 534) and in the inferior molars (Fig. 535) the internal and external trefoils respectively are strong, while the complementary trefoils in each tooth are more or less rudimentary.

Osborn, October, 1931: It would appear from the letters of Doctor Spillmann (June 6, July 2, 1930) cited above that the type and referred specimens (Figs. 534, 535, 548, 549 of the present Memoir) of *Cuvieronius ayoræ* represent a primitive Pleistocene stage quite distinct from any of the species of *Cuvieronius* previously described. So far as we can judge from the two American Museum specimens from Ecuador (Figs. 534, 535), the trefoils are *not double;* the external trefoils do not appear in the l.M[1] (Fig. 534), nor in the r.M_3 are the internal trefoils developed. Consequently, as Doctor Spillmann indicates in one of his letters, the species *ayoræ* may represent a specific stage distinct from members of the classic '*Mastodon' humboldtii* group to which the name *Cuvieronius* has been assigned. We await Doctor Spillmann's detailed description and figures[1] before this point can be settled, for in Doctor Spillmann's specimen the double trefoils may be better developed. Compare Ameghino's referred molar of *Mastodon* [=*Cuvieronius*] *rectus* (Fig. 546).

Osborn, 1933: This specific stage (*Cuvieronius ayoræ*), with 5½ ridge-crested molars and single trefoils, may prove to be related to *C. platensis* Amegh. Related also may be the following species, *C. postremus.*

Specific Characters.—Cranium, mandible, and tusks of same general proportions as in other species of *Cuvieronius* but more primitive and of smaller dimensions; superior tusks without enamel band and of elevated oval section as in *Cuv. postremus;* superior and inferior molars with large single internal and external trefoils respectively, little or no rudiment of double trefoils in either superior or inferior molars, thus differing widely from the type and paratype of *Cuv. humboldtii;* dimensions of male type cranium and tusks about ten per cent. greater than those of male type cranium and tusks of *Cuv. postremus.*

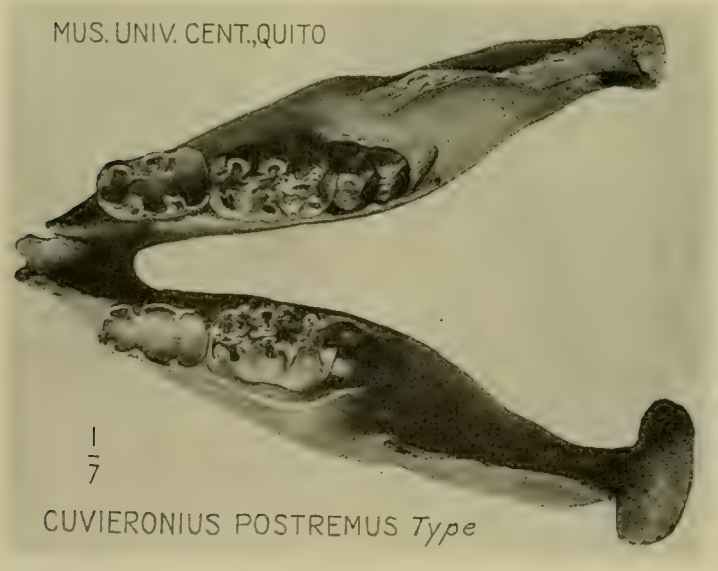


Fig. 550. Type mandible of *Cuvieronius postremus* from near Alangasi, Ecuador, in the Museum Universidad Central del Ecuador, Quito. After photograph. Compare Spillmann, 1931, opposite page 86. One-seventh natural size

[1]See footnote on page 573.

Comparative Measurements

(Spillmann, Letter, Sept. 22, 1931; cf. Spillmann, 1931.1, pp. 102–107)

	'*Bunolophodon*' *ayoræ*	'*Bunolophodon*' *postremus*
Length:		
Occipital crest to anterior border of premaxillaries	109	89
Occipital condyle to anterior border of premaxillaries	100	96
Occipital crest to tip of nasal process	27	31
Tip of nasal process to anterior border of premaxillaries	65	59
Occipital condyle to tip of superior incisive tusks	156.5	136.6
Height:		
Occipital condyle to summit of occipital crest	44	45
Length of femur		890
tibia	500	505
humerus	780	740
radius	670	630
Width of pelvis		1330

HABITS OF 'BUNOLOPHODON' AYORÆ AND OF 'BUNOLOPHODON' POSTREMUS SPILLMANN

(LETTER, SEPTEMBER 22, 1931)

Mastodonts similar to the *Cuvieronius* type lived in the high Cordilleras of Ecuador, since both '*Bunolophodon*' *ayoræ* and the short-limbed '*Bun.*' *postremus* were found at a height of about 2800 m. above sea level, somewhat as *Cordillerion andium* lived in the southern part of the Cordilleras. The *Cuvieronius* of Ecuador lived upon high grassy plains. The pre-orbital part of the skull is shortened while the postorbital part is lengthened and elevated.

These two new mastodont forms from the highlands of Ecuador are distinguished by the increased development of the cranium at the expense of the pre-orbital portion. In spite of the favorable living conditions under which '*Bunolophodon*' *postremus* persisted into prehistoric times, this species did not attain the specialization of the *Cuvieronius* species of the pampas. The author, agreeing with Boule and all previous writers, lays great emphasis on the difference between the cranial types described in the present Memoir under the generic terms *Cuvieronius* and *Cordillerion,* greater emphasis than on the evolution of the trefoils and the proportions of the grinding teeth; he also avers that the '*Mastodon*' *andium* form of the Cordilleras gave rise through successive evolutionary stages to the '*Mastodon*' *humboldtii* type, a conclusion from which the present author entirely dissents.

Cuvieronius postremus Spillmann, 1931

Figures 498, 530, 533, 536, and 550–552

Quebrada [canyon] of Cachihuayco, near Alangasi, Province of Pichincha, 13 kilometers east of Quito, Ecuador; superior Pleistocene, or prehistoric (*fide* Spillmann).

Bunolophodon postremus (Spillmann, letter, June 6, 1930). Described as Mastodonte de Alangasi in El Ecuador Comercial, 1928, Año VI, No. 57 (without name), p. 75; as 'Mastodon aus Alangasi' in Spillmann's "Das letzte Mastodon von Südamerika," Natur und Museum, Heft 2, No. 59, 1929, pp. 119–123 (1929.1), also in "Das südamerikanische *Mastodon* als Zeitgenosse des Menschen majoiden Kulturkreises," Pal. Zeits., Band 11, July 22, 1929, pp. 170–177 (1929.2). Full description and figures (with name) by Spillmann, "Die Säugetiere Ecuadors im Wandel der Zeit," 1931, pp. 73–107. See also Uhle's paper (1930) "Späte Mastodonten in Ecuador," Proc. Twenty-third International Congress of Americanists, September, 1928, pp. 247–258. TYPE.—Cranium with complete dentition; also associated skeleton. Mus. Univ. Cent., Ecuador. HORIZON AND LOCALITY.—Quebrada of Cachihuayco, Province of Pichincha, near Alangasi, 13 kilometers east of Quito, Ecuador. Superior Pleistocene or prehistoric (*fide* Spillmann). TYPE FIGURES.—*Op. cit.*, Spillmann, 1929.1, figs. 3, 4; associated skeleton, fig. 1.

TYPE DESCRIPTION.—For description (without name), cited from Spillmann (1929.2, pp. 175, 176), see pages 571–573 of the present chapter.

TYPE OF CUVIERONIUS POSTREMUS

Fig. 551. Type cranium of '*Bunolophodon*' *postremus* Spillmann, 1931, from near Alangasi, Ecuador, in the Museum Universidad Central del Ecuador, Quito, one-tenth natural size. After photograph. Compare same cranium in figure 530C, superior and palatal aspects

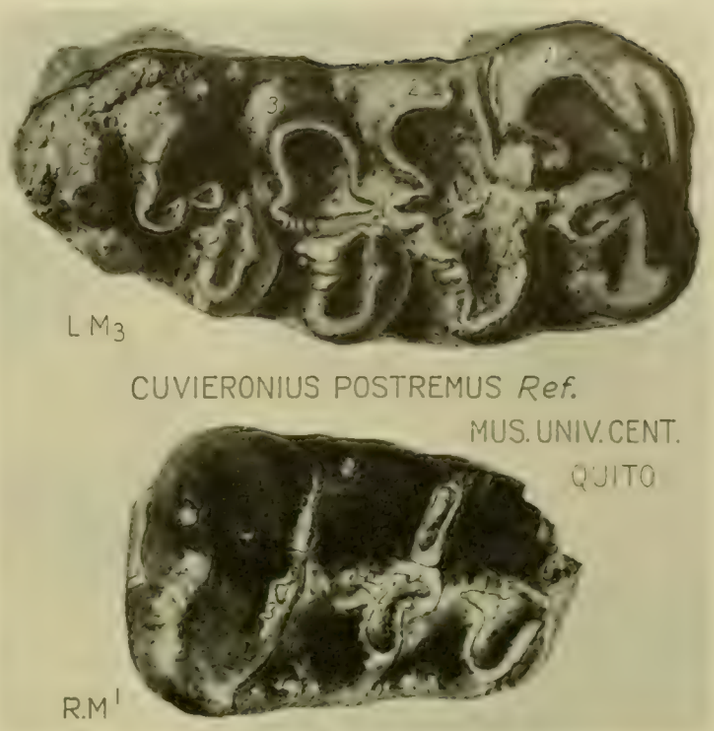


Fig. 552. Referred third left inferior molar, l.M_3, and first right superior molar, r.M^1, of *Cuvieronius postremus*. After photograph. See *C. rectus* ref. (Fig. 546, p. 581).

Osborn, August, 1931: The discovery of this most interesting type by Dr. Fr. Spillmann in April of 1928, is fully set forth in his own language on pages 571–573 above. The publication of Doctor Spillmann's complete description of the cranium and skeleton, in comparison with that of his *Tetrabelodon* (*Bunolophodon*) *Ayora*, was delayed.[1] His letters (June 6 and July 2, 1930) cited above indicate that the specific name *Bunolophodon postremus* is assigned. He proves that the species is of prehistoric age and regards it as entirely distinct from his *B. Ayora* as well as from the classic '*Mastodon*' *humboldtii*.

SPECIFIC CHARACTERS. Cranium, mandibles, and tusks of same general proportions as in other species of *Cuvieronius* but more primitive and of smaller dimensions; superior tusks without enamel band and of elevated oval section as in *Cuv. ayoræ;* superior and inferior molars with large single internal and external trefoils respectively, little or no rudiment of double trefoils in either superior or inferior molars, thus differing widely from the type and paratype of *Cuv. humboldtii* and agreeing with the type of *Cuv. ayoræ;* dimensions of male type cranium and tusks about ten per cent. less than those of male type cranium and tusks of *Cuv. ayoræ;* trunk and limbs (upper portions) widely different from those of *Cuv. platensis* or *Cuv. superbus;* humerus (740 mm.) and femur (890 mm.) relatively short, humero-radial and femoro-tibial indices relatively low, fore- and hindlimbs relatively short, with trunk carried closer to the ground than in either of the species of *Cuvieronius* inhabiting the plains of Argentina and Paraguay.

[1]See footnote on page 573.

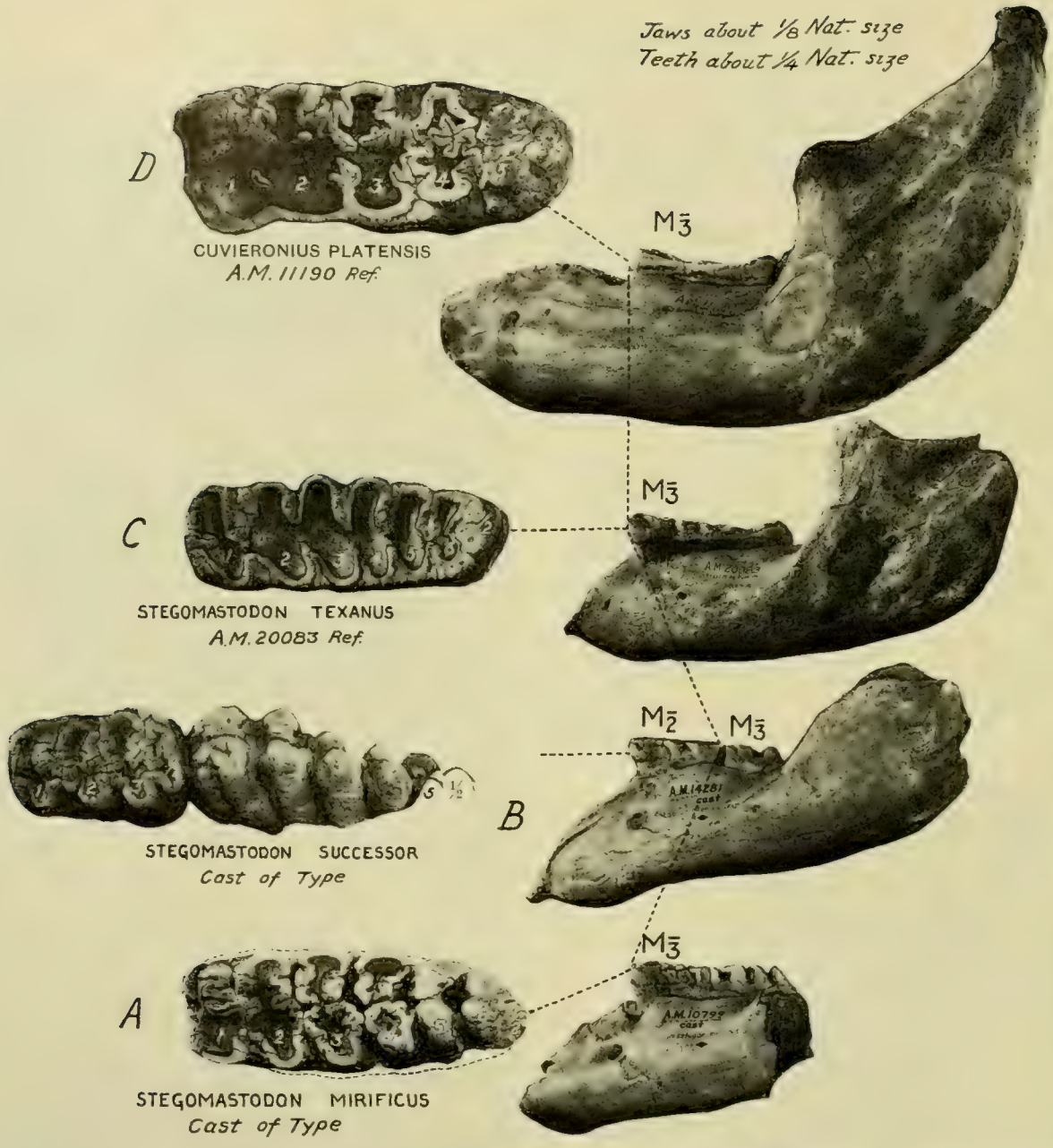


Fig. 553. Parallelisms and Divergences in Inferior Molars and Mandibles of Cuvieronius and Stegomastodon
Molars about one-fourth natural size; mandibles about one-eighth natural size

The comparison below demonstrates that *Stegomastodon*, a progressive Humboldtine, is wholly distinct both in its highly progressive grinding hexalophodont+teeth and abbreviated mandible from the pentalophodont+teeth of the Pampean *Cuvieronius platensis* ref.

D, Cuvieronius Osborn, 1923: Large infero-external trefoils, smaller infero-internal *double* trefoils.

Cuvieronius platensis ref. (Amer. Mus. Cope Coll. 11190). Buenos Aires, Argentina, Pampean. Well-worn l.M_3, 4–5½ ridge-crests, double trefoils, external larger and more worn; 252×99 mm.; internal border gently convex, external border gently concave; rudimentary 5th ridge-crest consisting of two appressed cones, small rudiment of 6th ridge-crest. Detailed characters of similar molars, r.M_{1-3}, see figure 554.

This mandible, with third inferior molar, l.M_3, closely resembles in form and size the aged female mandible figured by Cabrera as "*Stegomastodon*" *platensis* (1929, p. 106, fig. 10*b*, p. 107, fig. 11*b*), in which M_3 measures 205×85 mm. (*Op. cit.*, p. 106, fig. 10*b*): "mandibula de hembra vieja, Museo La Plata, n° 8–6 (×1/7)." Reproduced in the present Memoir (Fig. 562, D1).

C, B, A, Stegomastodon Pohlig, 1912: Subequal infero-internal and external *quadruple* trefoils.

C, *Stegomastodon texanus* Osborn, ref. (Amer. Mus. 20083— cf. type figure 642, B2, hexalophodont+). Aged individual. Progressive stage. Mandible with rostrum abbreviated; l.M_3, 6½ ridge-crests, strongly oblique, i.e., *proverted*, long and narrow, 204×73 mm.

B, *Stegomastodon successor* Cope, type. A young individual, l.M_2 with 3½ ridge-crests, strongly *proverted*, quadruple trefoils, 114×78 mm.; l.M_3 with 5½+ridge-crests, trefoils unworn, long and narrow, 191+×80e mm. Mandibular length 620 mm.

A, *Stegomastodon mirificus* Leidy, genotype. Symmetrical external and internal quadruple trefoils of the same size, deep median fissure; ridge-crests 5–6 narrower and less progressive than in *S. texanus;* M_3 222×80 mm. Mandibular length 416e mm.

6. SYNOPSIS AND CRITIQUE OF DR. ÁNGEL CABRERA'S REVISION OF THE ARGENTINE MASTODONTS, INCLUDING THE NEW GENUS AND SPECIES NOTIOMASTODON ORNATUS

"Una Revisión de Los Mastodontes Argentinos" by Dr. Ángel Cabrera, Chief of the Department of Palaeontology of the Museo de La Plata, published October 10, 1929. This richly illustrated Memoir of 140 pages, with complete bibliography of 81 titles (pp. 141–144), 35 admirably drawn text figures, including specimens in the collections of the La Plata Museum not previously illustrated or described, and two excellent colored illustrations, also full information regarding the geographic distribution of the type and referred material from the Province of Argentina, constitutes a timely and welcome addition to our knowledge of the mastodonts of South America.

Errors of Nomenclature and Classification

The four chief points of Nomenclature in Cabrera's Memoir which cannot be agreed to in the present Memoir are the following:

(1) In his introduction (pp. 61–80) Cuvier's type of *Mastodon humboldtii*, from Concepcion, Chile [?Ecuador] (Fig. 537 of the present Memoir), is erroneously interpreted (pp. 68, 69) as a milk tooth of *M. andium = hyodon*; Cabrera accordingly substitutes *Cuvieronius* Osb., 1923, for *Cordillerion* Osb., 1926, and defines the new subfamily Cuvieroniinae as embracing the *Mastodon andium* group, also the new genus and species *Notiomastodon ornatus*.

CUVIERONIUS

Fig. 554. Cuvieronius platensis Ref. of Argentina. First to Third Inferior Molars (Inferior Ridge-crests of M 3, 5½)

One-fourth natural size

Cuvieronius platensis ref. Right inferior molars, r.M_2, r.M_3 (Amer. Mus. Cope Coll. 11192), José Larroque collector; field Nos. 63–67 (see Ameghino, 1878, p. 57): "63 à 67—Dents molaires du *Mastodon andium* (Cuvier)." From Arreco, Buenos Aires, Argentina.

R.M_2, 3½ ridge-crests; double trefoils, broad external, narrow internal; 138×94 mm.

R.M_3, 5½ ridge-crests; trefoils, broad external, narrow internal; external side gently concave, internal side gently convex; 224×89 mm.; combined length of M_2, M_3, 362 mm.

Observe a similar mandible and convexo-concave molar, l.M_3, in figure 553D of *Cuvieronius platensis*. Also compare with 5½ ridge-crested convexo-concave l.M_3 (240×91 mm.) referred by Cabrera to *platensis* (Fig. 560).

In Cuvier's *type* from Chile [?Ecuador] (Fig. 537) and *paratype* from Bolivia (Figs. 538, 559) of '*Mastodon' humboldtii* the two posterior ridge-crests and talonid of M_3 are parallel in evolution to M_3 of *Cuvieronius platensis*.

Fig. 555. Second Cervical Vertebræ (Axis). After Cabrera, 1929, Fig. 1

A) Mus. La Plata 8–145. Relatively high, narrow axis of *Cordillerion andium* (referred to *Cuvieronius hyodon* by Cabrera). From Tarija.

B) Mus. La Plata 310. Broad and heavy axis of "cotipo" *Mastodon* [= *Notiomastodon*] *argentinus* (referred to *Mastodon argentinus* by Cabrera).

For these insufficient reasons the classic specific name *Mastodon humboldtii* is abandoned by Cabrera, but it is retained in the present Memoir as the genotypic species of *Cuvieronius;* also the new subfamily Cuvieroniinae Cab. is substituted for the subfamily name Notorostrinæ Osb., 1921, and the new family name Gomphotheriidae Cab. is substituted for the family name Bunomastodontidæ Osb., 1921.

It is true that Cuvier's *type* or first mentioned specimen (Fig. 537) is of somewhat indefinite character, but the *paratype* [Cuvier, 1806.3, pl. 67 (II), fig. 12, reproduced in facsimile as Fig. 538 of the present Memoir]

leaves absolutely no doubt as to the validity of Cuvier's original specific description of *Mastodonte humboldien* [see Cuvier's original definition of the species as cited in Chap. V, p. 123, also the full description and discussion on pp. 576–578 of the present Memoir].

(2) A second departure by Cabrera from the Cuvierian nomenclature is the substitution of Fischer de Waldheim's specific term *Mastotherium hyodon* for Cuvier's now classic *Mastodon andium* which pervades the entire literature from 1806–1824 to the present time.

For reasons fully set forth in the present Memoir this classic mountain-loving species is referred to throughout as Cordillerion andium, a collective species.

(3) A third departure from the nomenclatural standards of the present Memoir is Cabrera's erroneous reference to the genus *Stegomastodon* Pohlig of the classic *Mastodon humboldtii* Cuv. of the entire previous literature. Pohlig based the genus *Stegomastodon* on the species *Mastodon mirificus* Leidy, a type which both in its molar and mandibular structure (as shown in Figs. 553, 638 of the present Memoir) is generically different from the classic *Mastodon humboldtii* Cuv. of all previous authors.

(4) A fourth departure is the abandonment by Cabrera of the specific terms applied to the species and subspecies of the *Mastodon humboldtii* group in the sense used by all previous authors, namely, *humboldtii, chilensis, brasiliensis, bonaerensis, maderianus,* and the retention only of *platensis* and *superbus* Ameghino, 1888.

The profound alteration both of the generic and specific nomenclature of all previous literature (1806 to 1930) makes it impossible for us to apply the reasonable rules of classic priority which have been set forth in Chapter II, Sec. I, 1–5, of the present Memoir. Moreover, the relation of *Stegomastodon* to the '*Mastodon*' *humboldtii* type renders Doctor Cabrera's *generic* and *subfamily* classification very difficult to understand, and impossible to follow. In phylogeny he is no less difficult; and his radical alterations in the nomenclature make it impossible to follow his geographic, stratigraphic, and phylogenetic conclusions (pp. 136–140).

Errors of Phylogeny and Classification

Phylogeny.—Cabrera discusses at length (pp. 73–80) the phylogenetic and subfamily relationships of the South American mastodonts, ending (p. 80) with the following new classification:

a. Incisivos con banda de esmalte (*Cuvieroniinae*).
  b. Cúspides de los molares formando, por desgaste, tréboles a un solo lado; incisivos retorcidos.
    Cuvieronius hyodon (Fisch.).
  b'. Cúspides de los molares formando, por desgaste, tréboles en ambos lados; incisivos simplemente encorvados.
    Notiomastodon ornatus sp. n.

a'. Incisivos sin banda de esmalte (*Anancinae*).
  c. Perfil anterior del cráneo cóncavo; incisivos relativamente delgados y muy poco encorvados, en las hembras rectos.
    Stegomastodon platensis (Amegh.).
  c'. Perfil anterior del cráneo convexo; incisivos gruesos y bastante encorvados.
    Stegomastodon superbus (Amegh.).

Cabrera's new subfamily and generic arrangement is as follows (p. 76):

"III. **Cuvieroniinae** (=*Notorostrinae*, en parte, Osborn). Sínfisis mandibular corta; incisivos superiores con banda de esmalte, los inferiores normalmente ausentes." [Cabrera includes within this Andean subfamily the entire list of species placed in the present Memoir (pp. 549–566) within the genus *Cordillerion*, namely (pp. 80–90), [*humboldtii-hyodon-andium*], *cordillerarum, andii, andicus, argentinus, chilensis, bolivianum, tarijensis, edensis, gratus, orarius, tropicus, oligobunis.* In brief, Cabrera replaces *Cordillerion* Osborn, 1926 (type *Mastodon andium*), by *Cuvieronius* Osborn, 1923 (type *Mastodon humboldtii*)].

"IV. **Anancinae** (=*Notorostrinae*, en parte, y *Brevirostrinae* Osborn). Sínfisis mandibular corta; incisivos superiores sin banda de esmalte [Footnote: 'Al decir que falta el esmalte en las defensas me refiero siempre, naturalmente, al aspecto definitivo de las mismas. Es muy probable que en todos los mastodontes, como ocurre en los elefantes actuales, los incisivos, al salir, tuviesen la punta revestida de esmalte, que desaparecería muy pronto por desgaste. Los incisivos de leche de *Anancus arvernensis*, por lo menos, presentaban este revestimiento terminal de esmalte (Schlesinger, 1917, pág. 133).'], los inferiores normalmente ausentes." [This new Argentine subfamily includes the *Mastodon humboldtii* group of all previous authors. Accordingly Cabrera (pp. 96–140) arranges under the genus *Stegomastodon* all the species described in the present Memoir

(pp. 576–585) under the genus *Cuvieronius*, as well as all true North American species of *Stegomastodon* described in the present Memoir. Thus (pp. 96–140): *Mastodon humboldtii* is omitted because the type is supposed to belong to *Mastodon andium;* there follow the species *Stegomastodon platensis* (pp. 97–119), *S. bonaerensis*, *S. rectus*, *S. maderianus*, *S. superbus*, and *S. pirayuiensis* (pp. 120–135) which the author condenses within two species, namely, *Stegomastodon platensis* (pp. 97–119) and *S. superbus* (pp. 120–135).]

In brief, Cabrera admits only two principal historic species of Argentine mastodonts of the *Mastodon humboldtii* group, namely, *platensis* and *superbus*, thus differing from most authors of recent date, including Ameghino, 1888, 1889, who distinguish four species, *M. platensis*, *M. rectus*, *M. humboldtii*, *M. superbus*. To these he adds *Notiomastodon ornatus* as set forth below.

Geologic Succession and Human Association

As to geologic or stratigraphic succession, Cabrera observes (translation, p. 138):

> Nevertheless, the small amount of trustworthy data which there is tends to prove that *Stegomastodon superbus* is more recent than *S. platensis*, and it is a significant fact that in some cases there have been encountered the two species, on separate occasions, in the same locality (in Salto and in Mercedes). Moreover, seeming little likely, because of ecological incompatibility, that two animals so closely related to each other coexisted in the same site, it seems logical that they belong to distinct horizons. In this connection, I may note that in the two cases in which we have remains of the two species of *Stegomastodon* from the same locality, their fossilization is not precisely identical, that of *platensis* being more fragile and somewhat darker in color than that of *superbus*.
>
> There can be no contradiction, however, to the opinion of Ameghino on the stratigraphical distribution of these two proboscideans, out of which he makes no fewer than five distinct species; *Stegomastodon platensis* (=*platensis*, *rectus* and *maderianus*) is almost certainly from the middle and lower Pampean, and *S. superbus* (including *superbus* and *humboldti* of Ameghino) seems to correspond to the upper Pampean. There can hardly be any doubt as to which is the most recent species existing before the appearance of man in South America.
>
> [*Human Association.*—] As I have said, I have reason to believe that the remains of the mastodon found in Córdoba by [A.] Castellanos [1921], of which he figures the tip of an incisor artificially carved to convert it into a utensil,[1] are in reality *S. superbus*, and it would seem opportune to record here that in Ecuador there seems to be fully confirmed the contemporaneity with primitive man of a proboscidean which appears to belong to the same genus (Spillmann, 1929).

Summary of Cabrera's Memoir (Osborn, 1931)

To summarize, it is found impossible to adopt Cabrera's nomenclature, classification, and revision without disrupting and rearranging the entire previous literature on the subject from Cuvier down to the present time, including the nomenclature of the present Memoir.

It is, however, a pleasure, to set forth much new and valuable information contained in Dr. Cabrera's work and to reproduce the greater part of his most admirable illustrations. Such reproduction has been rendered possible through his great courtesy in loaning to the American Museum the excellent original pen drawings of his figures 1 to 35. These figures have been reassembled chiefly under the specific names which he adopts, namely:

Notiomastodon ornatus (figs. 2–5), a new and well defined genus.

Stegomastodon [=*Cuvieronius*] *platensis* (figs. 6–23), including (*fide* Cabrera) *Mastodon humboldtii*, *M. bonaerensis*, *M. rectus*, and *M. maderianus* of previous authors.

Stegomastodon [=*Cuvieronius*] *superbus* (figs. 24–35), including *M. humboldtii* in part (*fide* Burmeister), *M. superbus* Ameghino, *M. rectus* Ameghino, in part, *M. pirayuiensis* Gez.

Fig. 556. *Cuvieronius superbus* ref. Tip of tusk discovered in the Middle Pampean, Valley of the Reartes (Sierra de Córdoba), Argentina, and described by Alfredo Castellanos in his article "La Presencia del Hombre Fósil," 1921, pp. 378–380, Lam. VI, VII. One-third and five-sixteenths natural size respectively.

On certain figures thus reassembled we have taken the liberty of introducing the generic names *Cordillerion* and *Cuvieronius* to which these species respectively are referred in the present Memoir.

[1]Dr. Nels C. Nelson (letter, Nov. 4, 1935) questions the authenticity of this specimen as an artifact. (Osborn, Nov. 4, 1935) On the basis of an enamel tip, this specimen may be referable to *Notiomastodon*.

FAMILY: SERRIDENTIDÆ fam. nov.[1]
SUBFAMILY: SERRIDENTINÆ Osborn, 1921[1]; NOTIOMASTODONTINÆ subfam. nov.[1]

Genus: NOTIOMASTODON[2] Cabrera, 1929

Genotypic species: *Notiomastodon ornatus* Cabrera, 1929.
Original reference: Cabrera, "Una Revisión de Los Mastodontes Argentinos," Rev. Mus. La Plata, 1929, XXXII, p. 90.

Mastodontes con la mandíbula de sínfisis corta y desprovista de incisivos, los incisivos superiores sencillamente encorvados en todas las edades, y con una banda lateral de esmalte, y las muelas bunolofodontas y con los conos de las dos series acompañados de cónulos accesorios, produciéndose por desgaste una doble serie de tréboles.

El genotipo es *N. ornatus*, del Pleistoceno inferior argentino, que describo a continuación.

Considero necesario formar un nuevo género con el único mastodonte que conozco con los expresados caracteres, por no encontrar, entre los géneros ya establecidos, otro en que pueda ser incluído. Todos los demás mastodontes con banda de esmalte en las defensas son *Gomphotheriinae* o *Rhynchotheriinae*, es decir, tienen sínfisis mandibular muy larga e incisivos inferiores, aparte de las especies del género *Cuvieronius*, tan características por la forma retorcida de sus incisivos, y que además tienen los molares diferentes, con cúspides truncadas en trébol a un solo lado. Gidley (1926, pág. 85) ha descrito, con el nombre de *Anancus bensonensis*, un mastodonte del Plioceno de Arizona que, por la forma de sus molares, pudiera muy bien pertenecer a este género, pero no se conoce con seguridad el aspecto de sus defensas, si bien dicho autor piensa que podrían atribuírsele algunos fragmentos con banda de esmalte hallados en la misma localidad.

Notiomastodon ornatus Cabrera, 1929

Figures 498, 557, and 581a, also Pls. IX and XII

From Monte Hermoso, Province of Buenos Aires, Argentina. "Probablemente, Pleistoceno inferior."

Notiomastodon ornatus Cabrera, 1929. "Una Revisión de Los Mastodontes Argentinos," Rev. Mus. La Plata, Vol. XXXII, p. 91.

"*Tipo.*—Rama mandibular derecha de un individuo semiadulto (m_1 medio desgastado y m_2 saliendo) y una defensa del mismo, obtenidas por el señor Ignacio Lista en la Playa del Barco, Monte Hermoso, provincia de Buenos Aires. Colección del Museo Nacional Bernardino Rivadavia, n° 2157."[1] [Fig. 557 of the present Memoir.]

"*Distribución.*—Hasta ahora, sólo se conoce esta especie de la provincia de Buenos Aires, siendo la localidad típica la única determinada con seguridad."

"*Horizonte.*—Probablemente, Pleistoceno inferior. El yacimiento típico ha sido atribuído por Ameghino (1908) a su Peuelchense, por Kraglievich (1926) al Pampeano inferior cuspidal, por Frenguelli (1928) al Lujanense, que este autor sitúa en el comienzo del Postpampeano, y por Castellanos (1928) al Belgranense. Lo que se puede afirmar, es que su fauna es francamente pampeana, pero con características muy primitivas (formas pequeñas, presencia de *Typotherium*, etc.)."

AUTHOR'S DESCRIPTION OF TYPE TUSK[2] (FIG. 557C) AND OF RIGHT INFERIOR MANDIBLE (FIG. 557D)

The following citations are from Cabrera's Memoir of 1929 (pp. 92, 93) regarding the type of *Notiomastodon ornatus* in the Museo Nacional Bernardino Rivadavia, No. 2157[1]:

"*Descripción.*—Juzgando por los escasos restos de que hasta ahora se dispone, *Notiomastodon ornatus* era un mastodonte de tamaño pequeño, comparado con las otras especies sudamericanas; probablemente, no mucho mayor que *Elephas sumatranus* Temminck, o que *Loxodonta cyclotis pumilio* Noack (Pohle, 1926, pág. 60). Sus defensas, suavemente encorvadas, disminuyen gradualmente de grueso, y presentan una banda de esmalte próximamente paralela al plano de curvatura del diente y muy bien marcada, sobre todo hacia la punta, donde es plana y sobresale en fuerte relieve (figs. 2 y 3). Por comparación con otros mastodontes, puede deducirse que la banda era lateral externa, estando los incisivos encorvados hacia arriba y un poco hacia afuera; no creo que lo estuvieran hacia abajo, porque en los mastodontes en que ocurre así, como son los géneros longirrostros o *Cuvieronius hyodon* joven, la curva nunca es tan pronunciada como la que ofrece el incisivo adulto del Museo de La Plata (fig. 3*b*). La anchura de la banda es, aproximadamente, igual a un sexto de la circunferencia del diente. Las dimensiones del incisivo del tipo, que está incompleto en la raíz, y de dicho ejemplar adulto, son las siguientes [see below, p. 592]:"

"El ancho de la banda de esmalte en el incisivo completo del Museo de La Plata no puede apreciarse con exactitud porque, salvo en la punta, está muy destruída, siendo en algunos sitios difícil distinguirla del cemento, que también está mal conservado."

"El m_1, y el m_2 son trilofodontos, con las crestas divididas en dos cúspides, como en todos los mastodontes bunolofodontos. Cada una de las cúspides consiste en un gran cono que del lado interno, o sea hacia la línea media del diente, presenta un rudimento de cónulo accesorio, y además lleva delante y detrás, y siempre junto a dicha línea media, un cónulo bien señalado; de modo que el desgaste del molar produce un truncamiento en doble serie de tréboles, un poco más grandes los de la serie externa por ser las cúspides de este lado mayores que las opuestas. En el ángulo antero-externo del diente

[1](Osborn, July, 1934—see Osborn, 1935.937, fig. 2). Original specimens loaned by the Museo Argentino de Ciencias Naturales (in Buenos Aires)—formerly known as the Museo Nacional Bernardino Rivadavia—prove that *Notiomastodon* is a specialized South American migrant of the Serridentidæ. In the Appendix to this Volume (I), the present author removes this genus from the subfamily Serridentinæ and makes it the type of a new subfamily, the Notiomastodontinæ; he also defines the Serridentidæ fam. nov.

[2](Simpson, letter, Sept. 25, 1931) "The tusks of *Notiomastodon ornatus* have never been found in the skull and even their alveoli are unknown. Cabrera points out that allied forms with comparable tusk curvature and without tusks in the lower jaw generally have the tusks curving upward, and in those with a downward curvature this is generally less than in *ornatus* and tusks are generally present in the lower jaw."

hay una serie de pequeñas cúspides incipientes, que forman como un comienzo de cíngulo muy finamente dentado, y también aparecen indicios de cúspides pequeñitas en los bordes laterales de la corona, a la salida de los valles o espacios que quedan entre las crestas. Detrás de la tercera cresta hay un pequeño cono central, acompañado por el lado lingual de una corta serie de cónulos cada vez más chicos, formando medio talón (fig. 4)."

AUTHOR'S DESCRIPTION OF REFERRED MOLAR

Cabrera's description (1929, pp. 93, 94) of a third right inferior molar, which he referred to *Notiomastodon ornatus*, is as follows:

"El m_3, tiene cuatro crestas, la última bastante más estrecha que la penúltima por la notable reducción de su cúspide externa, y todas parecidas a las de los otros dos molares; pero, a diferencia de éstos, presenta un talón compuesto de seis o siete conos pequeños, uno central y los demás dispuestos a su alrededor, lo que hace que por el desgaste resulte una figura parecida a una roseta (fig. 5). En los individuos muy viejos, este dibujo tiende a perderse, porque a causa del excesivo desgaste se funden entre sí los círculos de esmalte correspondientes a dichos conos."

MATERIALS

Type (Mus. Nac. Bernardino Rivadavia 2157[1]): Right mandibular ramus containing M_1 with M_2 partly erupted (Cabrera, fig. 4, p. 93), also right superior tusk (*op. cit.*, fig. 2, p. 91), figure 557 D, E, C of present Memoir. From Monte Hermoso, Province of Buenos Aires, Argentina.

Referred (Mus. Nac. Bernardino Rivadavia[1]): "La mandibula, incompleta, de un individuo muy viejo, conservando en ambos lados el m_3 muy gastado, de Playa del Barco (n° 9445). Creo poder atribuir también a la misma especie una rama mandibular derecha, sin ningún dato de localidad, que tenemos en el Museo de La Plata (n° 8–52), y que corresponde a un ejemplar todavía joven, con el dm_4 *in situ* y el m_1 saliendo, así como un atlas incompleto que figura en la misma colección (n° 8–195), igualmente sin indicación de procedencia [p. 92]."

Refferred (Mus. La Plata): No. 8–53. Fragment of right mandibular ramus of an adult individual (M_3 moderately worn, Cabrera, *op. cit.*, fig. 5, p. 95), Monte Hermoso, Argentina. No. 8–47. Point of an adult superior incisor of the right side (*op. cit.*, fig. 3*a*, p. 92—Fig. 557A); Province of Buenos Aires. No. 8–45.

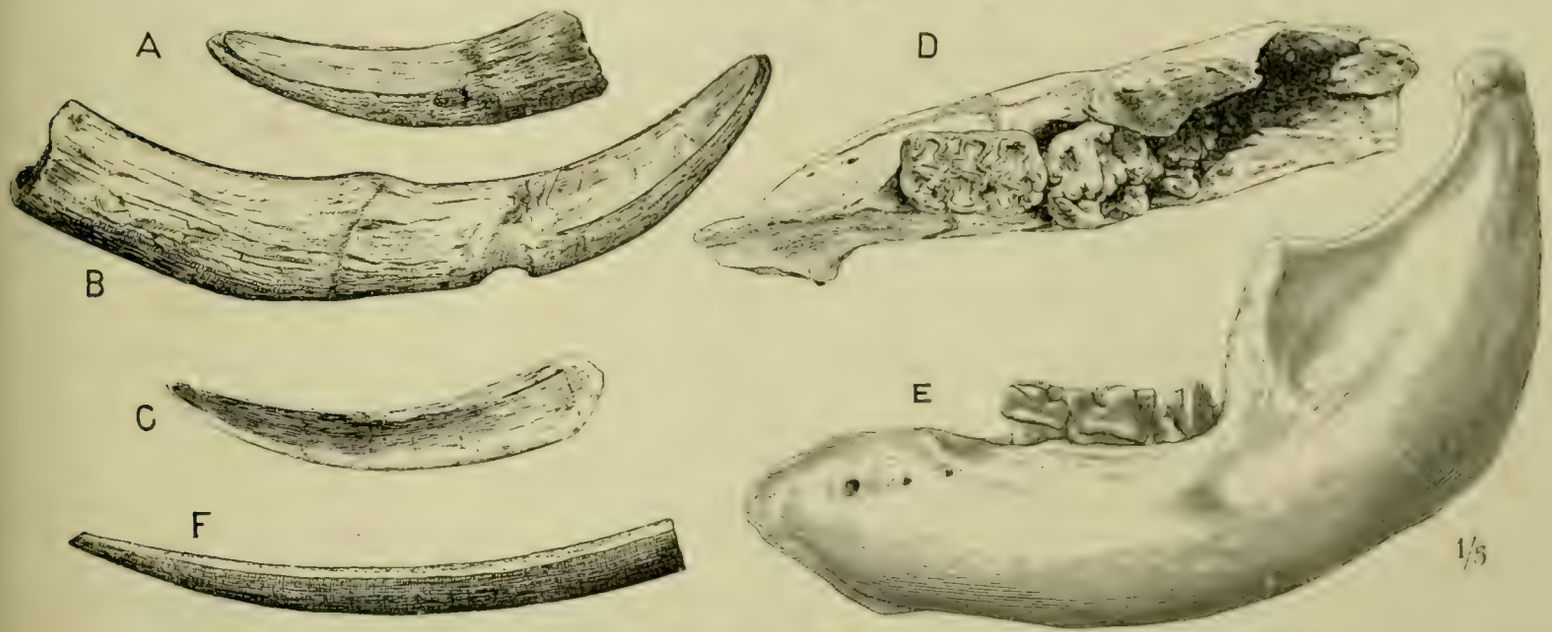


Fig. 557. (A–C) Notiomastodon ornatus Type and Referred Tusks, (D, E) Type Jaw,[2] (F) Type Tusk of Mastodon [= Notiomastodon] argentinus. Compare Plate xii in Appendix to the present Volume I.

After Cabrera, 1929, assembled from figures 2 (type tusk), 3 (referred tusks), 4 (type mandible). Tusks uniformly reduced to one-fifteenth natural size; mandible to one-fifth natural size.

It seems probable that all these tusks, as restored herewith, should be *downturned* rather than upturned as in the above illustration after Cabrera and Ameghino.

A, Point of an adult tusk (Mus. La Plata 8–47), after Cabrera, fig. 3*a*, p. 92. Length 640+ mm. From Province of Buenos Aires, Argentina.

B, Complete adult tusk (Mus. La Plata 8–45), after Cabrera, fig. 3*b*, p. 92. Length 1390 mm. From Province of Buenos Aires, Argentina.

C, Type tusk (Mus. Nac. Bernardino Rivadavia 2157[1]), after Cabrera, fig. 2, p. 91. Length 730+ mm. One-fifteenth natural size. From Monte Hermoso, Province of Buenos Aires, Argentina.

D, Type right inferior mandible (Mus. Nac. Bernardino Rivadavia 2157[1]); juvenile with r.M_1 (108×65 mm.) in use, r.M_2 (145×74 mm.) not erupted. One-fifth natural size. After Cabrera, fig. 4, p. 93.

E, Lateral view of type ramus of *Notiomastodon ornatus* Cabrera, bearing the inscription: "2157. Ramus mandibular de Mastodon. Form. pampeana. Playa del Barco, M. Hermoso." Drawn after original type kindly loaned to the American Museum by the Museo Argentino de Ciencias Naturales.

F, *Mastodon argentinus* type tusk, with broad enamel band, not spiral; otherwise resembling *Cordillerion andium*. After Ameghino, 1889, p. 644 (see Fig. 510 of the present Memoir). Referred to *Notiomastodon argentinus* in present Memoir.

[1]Now known as the Museo Argentino de Ciencias Naturales (in Buenos Aires).

[2]This type mandible is refigured in the Appendix of this Volume (Pl. xii).

Adult tusk complete but superficially eroded (*op. cit.*, fig. 3*b*, p. 92—Fig. 557B;) Prov. of Buenos Aires.

The above materials include remains of three incisive teeth of different ages but identical in character, as reproduced in our figure 557, also a young lower jaw and a complete third right inferior molar, which taken altogether give us an excellent idea of the characters of the genus *Notiomastodon* and species *ornatus*. The comparative incisive tusk measurements are as follows:

N. ornatus type tusk (Rivadav. Mus. 2157[1])	730+mm.
N. ornatus, complete adult tusk (Mus. La Plata 8–45)	1390
N. argentinus type tusk (cf. Fig. 510 of present Memoir).	1040e

Osborn, 1931: Observe that the smaller and more slender *type* tusk (Fig. 557C) and juvenile inferior *type* mandible (Fig. 557D,E) probably represent a female, as compared with the more robust referred tusks (Fig. 557A,B). Observe the *type* r.M_1 with conspicuous internal and external trefoils, cones placed opposite each other, and rudimentary tetartolophid. The *referred* r.M_3 (Mus. La Plata 8–53—see Cabrera, 1929.1, fig. 5, p. 95) is distinguished by large external trefoils, rudimentary internal trefoils, outer and inner cones obliquely placed, 4⅔ ridge-crests, and seems to be relatively more primitive than the type molars, M_1, M_2 (Fig. 557D). The type tusk of '*Mastodon*' *argentinus* (Fig. 557F) is much longer and more slender than that of *Notiomastodon ornatus*. Cabrera (*op. cit.*, pp. 86–89, 95) fully discusses Ameghino's type of '*Mastodon*' *argentinus* (Figs. 510, 557F) and wrongly believes that it is related to the '*Mastodon*' *andium* group. In the present Memoir this species is described as *Notiomastodon argentinus*, quite distinct in its non-spiral tusks from the typical *Cordillerion andium*.

It seems probable that all these tusks should be *downturned* rather than upturned as in the above illustration after Cabrera and Ameghino.

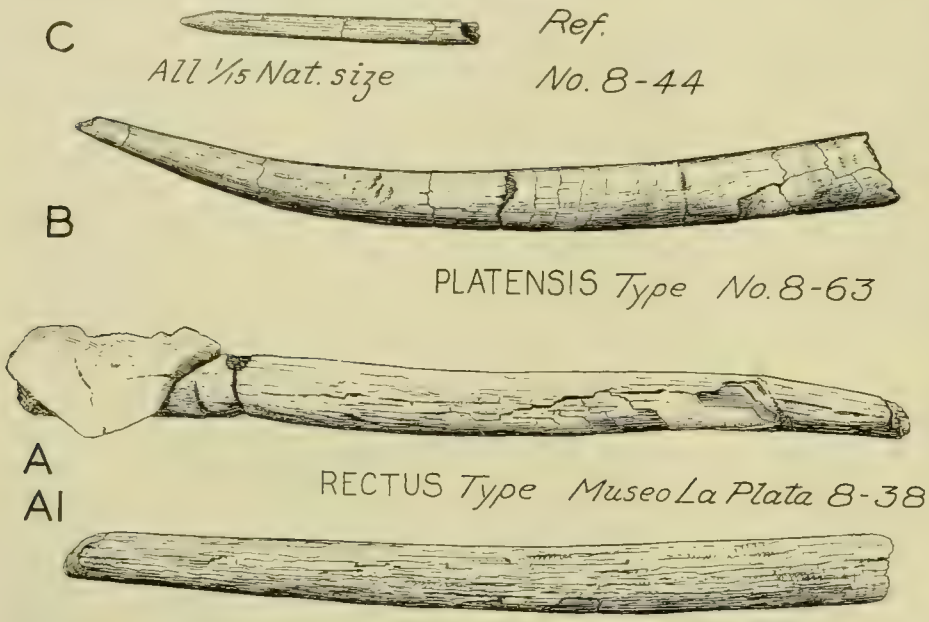


Fig. 558. Superior Incisive Tusks of (B) Cuvieronius platensis and (A, C) Cuv. rectus Inferior Pampean. After Cabrera, 1929, figures 13 and 14. One-fifteenth natural size

C, *Cuvieronius rectus* ref., female from Tapalqué, Province of Buenos Aires, Argentina. (Cabrera, 1929, fig. 14): "*Stegomastodon platensis:* defensa de hembra, Museo La Plata, n° 8–44. (×1/11)." Length 630 mm. This small, straight tusk resembles the female tusk of '*Mastodon*' *rectus* Ameghino, type.

B, *Cuvieronius platensis* Ameghino, type. Adult male from San Nicolás de los Arroyos, Province of Buenos Aires, Argentina. Dept. Pal. Mus. La Plata 8 63. For full description and figure see page 579 of the present Memoir. Length 1720 mm.

A, A1, *Cuvieronius rectus* Ameghino, type. Very aged male from La Ensenada, near La Plata, Argentina. Mus. La Plata 8–38. For full description and figure, see pages 580, 581 of the present Memoir. Originally figured by Ameghino (our Figs. 490 and 545).

Notiomastodon argentinus Ameghino, 1888

The original description of this species, the type of which is a superior tusk, appears on page 550, as the present author first regarded it as belonging to the genus *Cordillerion*. As explained on page 541, this species has now been transferred to Cabrera's genus *Notiomastodon*, 1929; it is illustrated in figures 510 and 557F of the present Memoir.

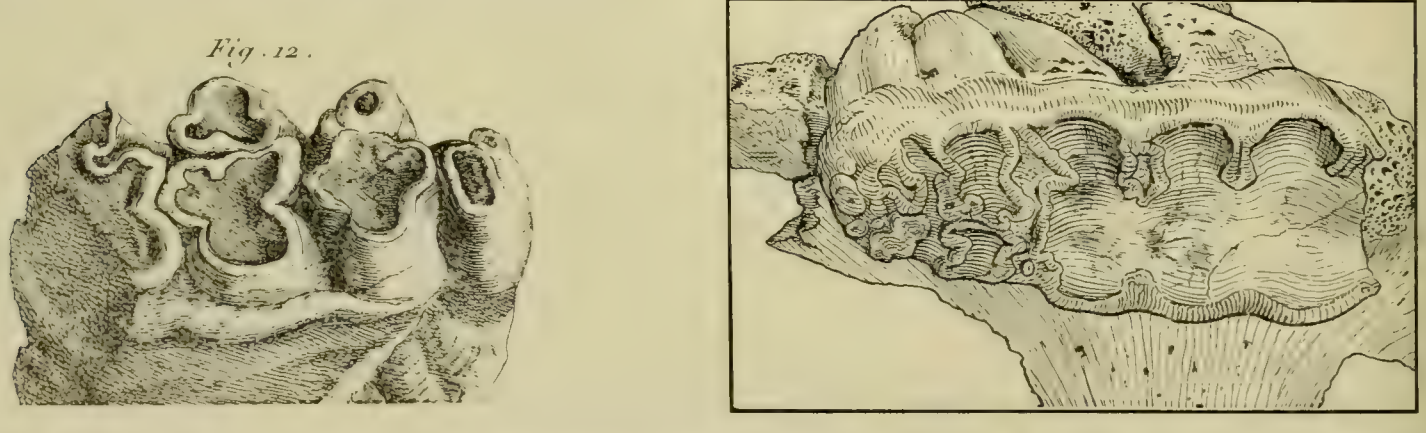


Fig. 559. (Left) '*Mastodon*' *humboldtii* Cuvier. Bolivia paratype, l.M_3, after Cuvier, 1806.3, Pl. 67 [11], fig. 12. Two posterior ridge-crests and talonid parallel in evolution to *Cuvieronius platensis*, l.M^3 (right).

(Right) *Cuvieronius platensis* Ameghino. Argentine referred l.M^3, after Cabrera, 1929, fig. 9. Left third superior molar, l.M^3, with 5 ridge-crests and biconed talon, closely parallel in evolution to '*Mastodon*' *humboldtii*, l.M_3 (left). Compare figure 562D, the same palate.

[1]See footnote 1 on page 591.

Review and Critique of Cabrera's Specific References, 1929

It seems ungracious to utilize the beautiful drawings placed at our disposal by Dr. Ángel Cabrera and at the same time to dissent from many of his *specific* references, as we have found ourselves obliged to do in the case of his *generic* references. By way of apology it may be said that in the present Memoir we have found it necessary to treat in the same manner the work of all authors, namely, to *revise unsparingly all ancient and modern work according to new phylogenetic standards*. In the present Memoir this has been done with such outstanding figures as Blumenbach, Cuvier, Falconer, Gaudry, Leidy, Cope, and Ameghino, in the same spirit in which we are now revising Cabrera and are preparing to revise Osborn's own work wherever it may prove not to stand the acid test of phylogeny.

Let us finally[1] consider Cabrera's synopsis of the undoubtedly more ancient and more primitive '*Stegomastodon*' [*Cuvieronius*] *superbus* in comparison with the more modern and possibly [Osborn] more recent [*Cuv.*] *platensis*.

Cuvieronius platensis Ameghino, 1888. Concave anterior profile of cranium. Tusks relatively slender or somewhat incurved, in females straight. Superior and inferior grinders with 5½ ridge-crests, cones opposite, La Plata Mus. 8–6 (Fig. 9). (Includes '*Elephas*' *Humboldtii* of de Blainville, *M. Humboldtii* of Laurillard, *M. andium* of Falconer and Cautley, *Dibelodon Humboldtii* Cope, *M. platensis* Amegh., *M. bonaerensis* Moreno, *Dibelodon cordillerarum* Cope, *M. rectus* Amegh., *M. maderianus* Amegh., and *Dibelodon platensis* Carette.)

Type.—An adult superior tusk from the Province of Buenos Aires (La Plata Mus. 8–63).

Distribution.—Chiefly from the Provinces of Buenos Aires, Santa Fé, and Entre Riós, also from Uruguay.

Horizon.—The typical horizon of '*M.*' *platensis*, according to Ameghino, is the Belgranense.

This species may be considered as belonging to the middle or lower part of the Pampean formation.

Materials.—Besides the type are numerous examples in the Museum of La Plata, portions of crania, of tusks, of lower jaws, and many parts of the skeleton. See figure 562.

Cuvieronius superbus Ameghino, 1888. Type. A pair of tusks and an adult mandible with M_3 much abraded. From Pergamino, Province of Buenos Aires (La Plata Mus. 8–8). Superior and inferior grinders with 4½ ridge-crests, double trefoils.

Type Figure.—Cabrera, 1929, fig. 28a. (Fig. 563 of the present Memoir.)

Distribution.—All the known remains of this species are from the northern part of the Province of Buenos Aires and the Province of Córdoba.

Horizon.—Superior Pleistocene. Ameghino attributes this species to his horizon Lujanense, or 'lacustrian Pampean.'

Materials.—A very incomplete skull, pelvis, femur, tibia, etc., from the Province of Buenos Aires (Mus. La Plata 8–3); cranium described by Ameghino as *M. Humboldtii*. (Includes specimens referred to *M. humboldtii* by Burmeister, to *M. humboldtii* by Ameghino, to *M. rectus?* by Ameghino, to *M. platensis* by Gez, to *M. pirayuiensis* by Gez, to *M. andium?* by Castellanos.)

The normal phylogenetic order of ridge-crest evolution in the Humboldtinæ is as follows:

Progressive stages with $6\frac{1}{2}$ to $7\frac{1}{2}$ ridge-crests, quadruple trefoils = *Stegomastodon aftoniæ* ($l.M^3$, Fig. 580).

Progressive stages with $5\frac{1}{2}$ ridge-crests and double trefoils = *Cuvieronius platensis*, ($r.M^3$, $l.M_3$, Fig. 560).

Ancestral stages with $4\frac{1}{2}$ ridge-crests and double trefoils = *Cuvieronius superbus* ($l.M^3$, $l.M_3$, Fig. 561).

Ancestral stages with $4\frac{1}{2}$ ridge-crests and single trefoils = *Cuvieronius ayoræ*; *C. rectus* ref. ($l.M^3$, Fig. 546).

Doubtfully Referred Molars. Both Ameghino and Boule define '*Mastodon*' *platensis* as possessing *single* trefoils, whereas Cabrera's (1929) figures reproduced on the next page (Fig. 560) exhibit *double* trefoils: since '*M.*' *platensis* was defined by Ameghino as possessing single trefoils, the molar shown in Cabrera's figure cannot typically be referred to '*M.*' *platensis*, of which '*M.*' *rectus* Amegh., '*M.*' *maderianus* Amegh., and '*M.*' *bonaerensis* Mor. are said by Cabrera to be synonymous.

The highly plicated '*M.*' *superbus* molars reproduced after Cabrera, in our figure 561, from the superior Pampean, Mercedes, are relatively short and broad, exhibiting (1) only four ridge-crests, (2) highly plicated entotrefoils on M^3 and highly plicated ectotrefoils on M_3, (3) small ectotrefoils on M^3 and small entotrefoils on M_3.

[1] See Appendix to the present Volume I, under the heading "The New Family Humboldtidæ."

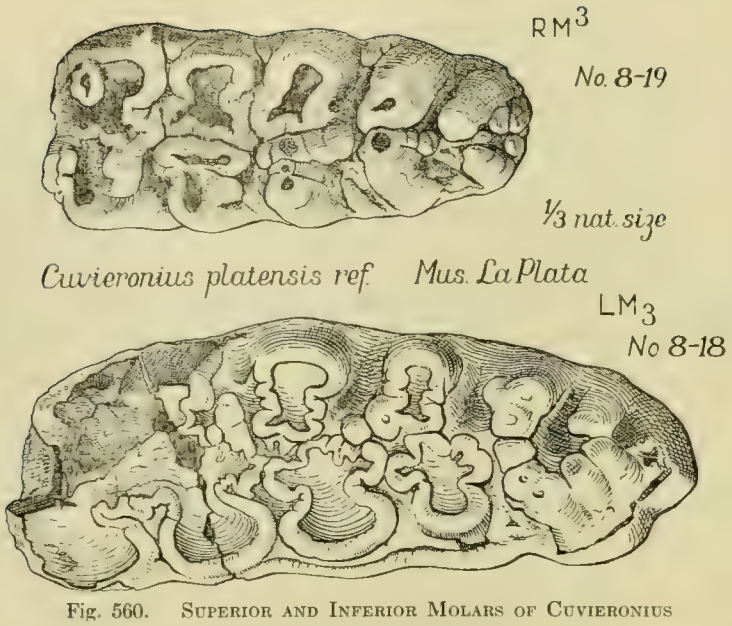


Fig. 560. Superior and Inferior Molars of Cuvieronius platensis Ref. (by Cabrera)

One-third natural size

Inferior or Middle Pampean. After Cabrera, 1929 (upper, fig. 15; lower, fig. 16). Superior ridge-crests *transverse*; inferior ridge-crests *proverted*.

(Cabrera, 1929, fig. 15): "*Stegomastodon platensis: m*^{3} derecho, Museo La Plata, n° 8–19. (×⅓)." (*Op. cit.*, p. 103): "M^3 con cinco crestas, la quinta muy pequeña y sin cónulos accesorios bien definidos, constituyendo más bien la primera parte de un talón que se completa con dos o tres cónulos posteriores (figs. 9, 15)."

(Osborn) Third right superior molar, r.M^3, biconvex, tetralophodont+ (4½+ridge-crests), double trefoils subequal in size, supero-internal more worn, 195×84 mm. Observe that this 4–5+ ridge-crested superior molar is relatively long and narrow, agreeing with the relatively long, narrow inferior molars of Mus. La Plata 8–6, measuring 205×85 mm.

(Cabrera, 1929, fig. 16): "*Stegomastodon platensis: m*$_3$ izquierdo, Museo La Plata, n° 8–18. (×⅓)." (*Op. cit.*, p. 103): "En el *m*$_3$ hay también cinco crestas, la última igualmente muy sencilla, aunque algo más grande que en el superior, y seguida también de dos o tres cónulos dispuestos en un grupito transversal (figs. 11, 12, 16)." From Capitán Sarmiento, Argentina.

(Osborn) Third left inferior molar, l.M$_3$, 5½ ridge-crests (pentalophodont+), double trefoils, infero-external slightly larger, more worn, 240×91 mm., plano-convex; pentalophid without trefoils, 6 conelets; hexalophid with 3 conelets.

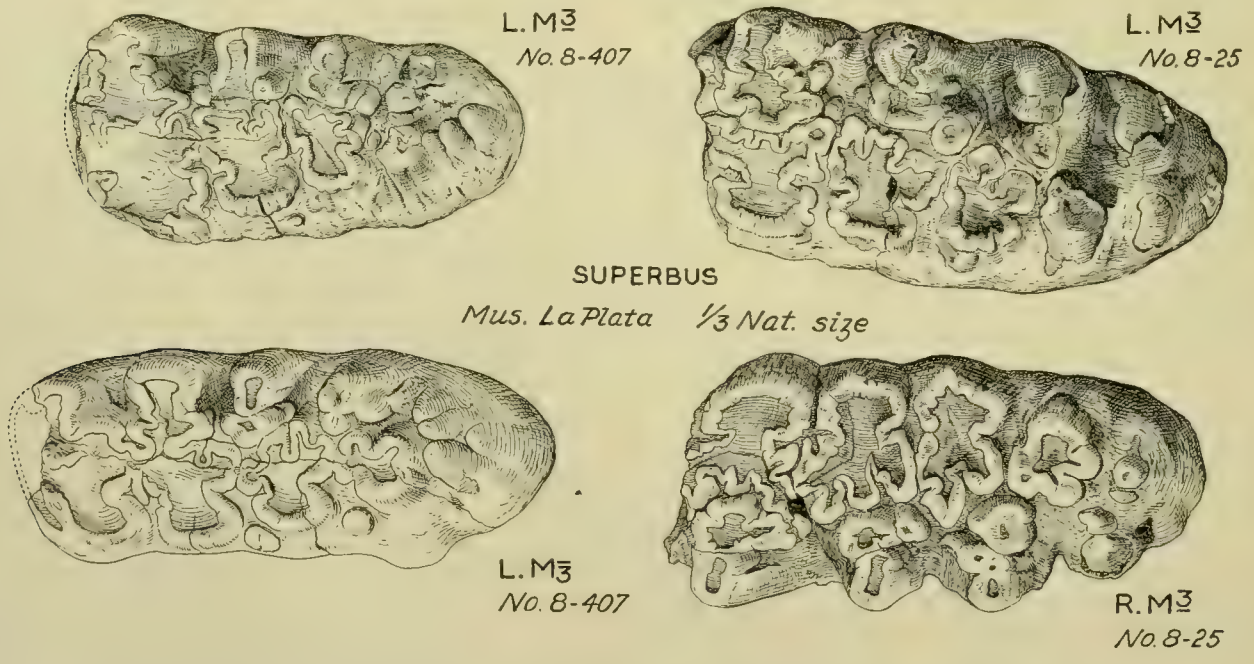


Fig. 561. Superior and Inferior Molars (4½ Ridge-crests) of Cuvieronius superbus Ref. (by Cabrera)

Female (left), male (right). One-third natural size

From superior Pampean, Mercedes, Province of Buenos Aires, Argentina. Reassembled after Cabrera's original drawings of '*Stegomastodon*' *superbus* (cf. 1929, figs. 29, 30). Mus. La Plata 8–407 and 8–25.

Fig. 29*a*. Mus. La Plata 8–407. Third superior molar, l.M^3, supero-internal trefoils larger, more worn, 185×90 mm., tetralophodont+ (ridge-crests, 4½), plano-convex. "Probablemente hembra."

Fig. 29*b*. Mus. La Plata 8–407; same individual. Third inferior molar, l.M$_3$, infero-external trefoils larger, more worn, 222×90 mm., tetralophodont+ (ridge-crests 4½+), concavo-convex.

Fig. 30. Mus. La Plata 8–25. Third superior molar, l.M^3, supero-internal trefoils larger, more worn, 220×100 mm., tetralophodont+ (4½ ridge-crests), biconvex.

Fig. 30. Mus. La Plata 8–25. Third superior molar, r.M^3, supero-internal trefoils larger, strongly plicate, tetralophodont+ (4½ ridge-crests), biconvex.

Geologic and Geographic Distribution of Species of Cuvieronius, Simpson, 1931

Throughout the present Memoir great importance is attached to the *geologic horizons or levels*, especially of the type specimens and of the genotypic species of the various genera. Unfortunately we have not very clear or positive records of the geologic horizons of any of the typical South American species. The following notes by Dr. George Gaylord Simpson (dated Buenos Aires, September 25, 1931) tend to confirm the records given by Dr. Ángel Cabrera:

Cordillerion. Nowhere in the Buenos Aires or La Plata collections is there any true '*Mastodon*' *andium* or *hyodon* from the plains region. It occurs along the Cordillera from Colombia to Chile. If it occurs in the Argentine at all, which is doubtful, it is only in the far northwest, in the Cordilleran zone. The other three Argentine species [*platensis, superbus, ornatus*] are confined to the extra-Andean zone and therefore do not occur in association with the Andean form. Authors who make statements to the contrary have correctly recognized the presence of two separate species in the pampa region, but have incorrectly identified these two species as '*andium*' and '*humboldtii*.'

Cuvieronius. The species *platensis* occurs in the Argentine provinces of Buenos Aires, Entre Ríos, and Santa Fé, and probably also in Uruguay, that is, in the plains region contiguous to the rivers Paraná and Uruguay and their estuary, the Plata.

The other species, *superbus*, is known from the northern part of Buenos Aires province (including the federal capital, the city of Buenos Aires) and the adjacent plains, part of the province of Córdoba. As an example, one of the best finds was made here (Buenos Aires) only a few weeks ago. The specimen is a good one and may surely be identified as *superbus*. With a number of Argentine scientists, I visited and studied the locality and saw part of the specimen in place, in an excavation in the heart of the city for a new subway. On the basis of a supposedly associated typothere, the horizon was at first considered as Lower Pampean. Later it appeared from conversation with a foreman that the specimens were not associated. Other data and further study have resulted in a rapid fluctuation of opinion from Lower to Middle to Upper Pampean and back again. Yet the data on this specimen are incomparably better than for almost any other known.

The two ranges overlap extensively, and both species seem to be typical of the pampa. Both species [*platensis, superbus*] have been confused with or considered as synonymous with *humboldtii* and in most of the literature it is impossible to know which is meant without a restudy of the particular specimen in question. [Osborn (1933). *Cuvieronius humboldtii* ridge-crests are much more primitive.]

Their horizons are commonly accepted as Lower and Middle Pampean for *platensis* and Upper for *superbus*. This is chiefly on the authority of Ameghino and the data are not wholly satisfactory. Few specimens are of exactly known origin, and even when this is known, the age is not always certain.

S. [*Cuv.*] *platensis* is smaller than *superbus* and its molars have fewer accessory cusps, but tend to have a higher number of crests. Its tusks are nearly straight and rather slender, while those of *superbus* tend to be more curved and very thick. To me it seems impossible to consider one as definitely more primitive than or ancestral to the other or to form any *a priori* judgment of their probable relative ages.

They have never been found together,[1] and it is to some extent unlikely that two species so similar and with nearly identical geographic ranges should be contemporaneous. There is some probability that *platensis* is older, but this is far from being an established fact.

Cabrera lists the geologic levels and localities of the types as follows:

Cuvieronius superbus (=*humboldtii*, and mastodon from Córdoba, see Castellanos, 1921), Pergamino, Province of Buenos Aires	Upper Pleistocene "seems to correspond to the Upper Pampean."
Notiomastodon ornatus, Monte Hermoso, Province of Buenos Aires	Probably Lower Pleistocene
Cuvieronius platensis (=*rectus*, =*maderianus*), San Nicolás de los Arroyos, Province of Buenos Aires	"Almost certainly from Middle or Lower Pampean," =?Lower Pleistocene

According to Cabrera and Simpson above, the posterior grinding teeth referred (Fig. 560) to *Cuvieronius platensis* appear to be more progressive,[2] that is, with more ridge-crests (5½) than the posterior grinding teeth referred (Fig. 561) to *C. superbus* (4½+), as shown in the excellent figures of Cabrera in the present section (6).

[1] *Cuvieronius superbus* is found in a *central* area of the Province of Buenos Aires. *C. platensis* is found in areas to the north and to the south of this central area.

[2] See Appendix to the present Volume I, under the heading "The New Family Humboldtidae," for remarks by Colbert as to the significance of the number of ridge-crests and the amount of enamel folding in the molars of these two species.

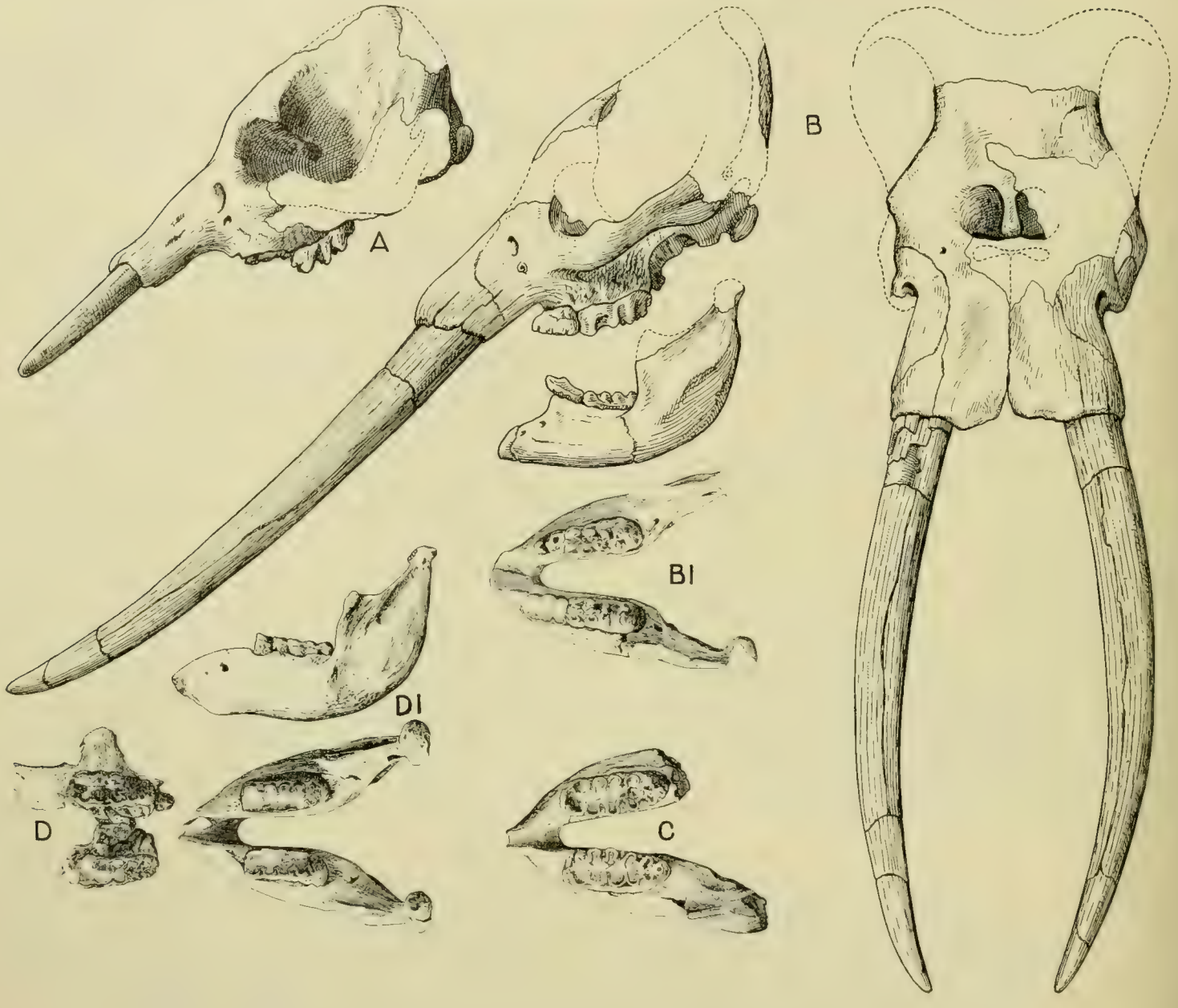


Fig. 562. (B) Type of Cuvieronius bonaerensis Moreno (cf. C. superbus Ameghino)
(A, C, D) Referred by Cabrera to Stegomastodon [=Cuvieronius] platensis Ameghino
Reproduced one-fifteenth natural size from Cabrera's Memoir of 1929, by courtesy of Dr. Ángel Cabrera
Assembled from Cabrera's figures of '*Stegomastodon*' *platensis:* 6–8 (crania and mandible), 9 (palate), and 10–12 (mandibles)

Note (Osborn, 1933).—The long, straight tusks and the 4½ molar ridge-crests appear to relate the cranium (B) and mandible (B1) to *Cuvieronius superbus* rather than to *C. platensis* (M $3\frac{-}{4\ 4½}$ cf. *superbus*).

A, Mus. La Plata 8–4. Cranium of young individual of *Cuvieronius platensis.* Mercedes, Province of Buenos Aires. Donation of José Larroque, who collected the Cope Pampean Collection of The American Museum of Natural History. After Cabrera, fig. 8, p. 101.

B, Mus. La Plata 8–1. Lateral and anterior views of adult cranium with restored occiput and left frontal region of the type of *Cuvieronius bonaerensis,* Arrecifes, Province of Buenos Aires, Argentina. After Cabrera, fig. 6, p. 99. B1, Jaws of same individual. After Cabrera, figs. 6, 7, 11*a*. (B) Ridge-crests (M^3) 4½, (M_3) 4½+. This classic skull in the Museo La Plata was made the type of *Mastodon bonaerensis* by Moreno in 1888 and figured by Carette in 1919 as *Dibelodon platensis* (see Fig. 532).

C, Mus. La Plata 8–50. Adult mandible of *Cuvieronius platensis,* lacking posterior half of right ramus. Observe 5½ ridge-crests. After Cabrera, fig. 12, p. 108.

D, D1, Mus. La Plata 8–6. Aged female maxilla (palatal view) and mandible (side and superior views) of *Cuvieronius platensis.* Salta, Province of Buenos Aires, Argentina. After Cabrera, figs. 9, 10*b*, 11*b*. For enlarged view of l.M^3, see figure 559 (right).

CUVIERONIUS SUPERBUS CRANIA AND MANDIBLES, AFTER CABRERA, 1929

Fig. 563. (A) Type; (B-E) referred by Cabrera to Cuvieronius superbus Ameghino, (B, C) referred by Osborn to C. platensis

Reproduced one-fifteenth natural size from Cabrera's Memoir of 1929. By courtesy of Dr. Ángel Cabrera
Assembled from figures 24*a*, 24*b* (crania), 25, 26 (mandible), 28 (tusks)

A, Mus. La Plata 8–8. Type superior tusk of an adult individual; length 2200 mm., mid-circumference 540 mm. Pergamino, Province of Buenos Aires, Argentina. After Cabrera, 1929, fig. 28*a*, p. 127.

A1, A2, Mus. La Plata 8–8. Type mandible, lateral and superior views. Pergamino, Province of Buenos Aires, Argentina. After Cabrera, 1929, figs. 25, 26*a*, pp. 123, 124.

B, Mus. La Plata 8–40. Tusk of a semi-adult [female] individual; length 1280 mm., circumference at base 450 mm., mid-circumference 445 mm. Locality unknown. After Cabrera, 1929, fig. 28*b*, p. 127. Observe greater curvature and resemblance to *C. platensis* ref.

C, Mus. La Plata 8–42. Tusk of a young individual from Mercedes, Province of Buenos Aires, Argentina. After Cabrera, 1929, fig. 28*c*, p. 127. Observe curvature resembling that of *C. platensis* ref.

D, D1, Mus. La Plata 8–3. Referred semi-adult cranium, with incomplete occiput and right premaxillary, left and anterior aspects. Matanzas River, Province of Buenos Aires, Argentina. After Cabrera, 1929, fig. 24*a*, *b*, p. 122. Compare figure 497 (cranium of *C. humboldtii* ref. in Paris Museum).

E, Mus. La Plata 8–157. Incomplete mandible, semi-adult, with alveoli of M_2, roots of M_3, and narrow rostrum. Associated with femur. Carlos Casares, Province of Buenos Aires, Argentina. After Cabrera, 1929, fig. 26*b*, p. 124.

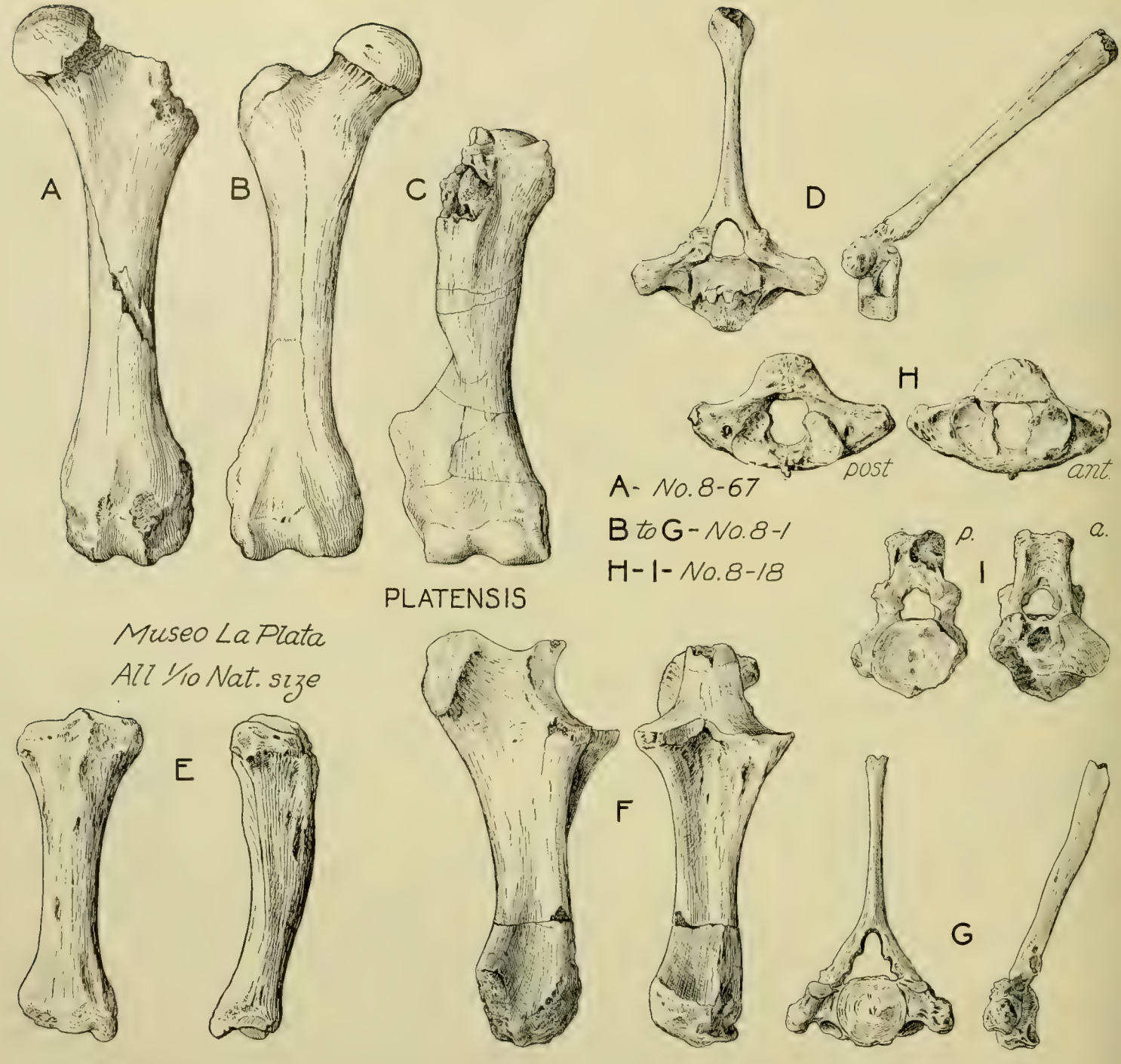


Fig. 564. (A, H, I) Cuvieronius platensis Ref., (B–G) Type Skeleton of Cuvieronius bonaerensis [=superbus] Mor. *Cuvieronius platensis* smaller, more slender than *C. superbus* (Fig. 565). Inferior Pampean. Uniformly reduced to one-tenth natural size

After Cabrera, 1929, assembled from figures 17 (atlas), 18 (axis), 19 (dorsals), 20 (humerus), 21 (ulna), 22 (femora), 23 (tibia). Observe that the femur, humerus, first and third dorsals, ulna, and tibia, are of one individual (*Cuvieronius bonaerensis*), also that the humerus, ulna, femur, and axis are smaller and much lighter in construction than those of *Cuvieronius superbus* shown in figure 565.[1]

Cuvieronius platensis ref. (Mus. La Plata 8–67) from the arroyo Chelforó, Ayacucho, Province of Buenos Aires, Argentina:

A, Left femur. Length 1030 mm. Fig. 22*b*.

Cuvieronius bonaerensis (Mus. La Plata 8–1); type skeleton of *Mastodon bonaerensis* Moreno, from Arrecifes, Province of Buenos Aires, Argentina:

B, Right femur. Length 980 mm. Fig. 22*a*.
C, Right humerus. Length 795 mm. Fig. 20.
D, Third dorsal. Fig. 19*b*.
E, Right tibia. Length 750 mm. Fig. 23.
F, Right ulna. Length 780 mm. Fig. 21.
G, First or anterior dorsal. Fig. 19*a*.

Cuvieronius platensis ref. (Mus. La Plata 8–18), from Capitán Sarmiento, Province of Buenos Aires, Argentina:

H, Atlas. Fig. 17.
I, Axis. Fig. 18.

[[1]Resemblances in the molar ridge-crests of '*M.*' *bonaerensis* to those of *Cuvieronius superbus*, as well as differences in the size and curvature of the incisive tusks from those of '*M.*' *platensis*, led the present author to relate '*M.*' *bonaerensis* to *C. superbus*.—Editor.]

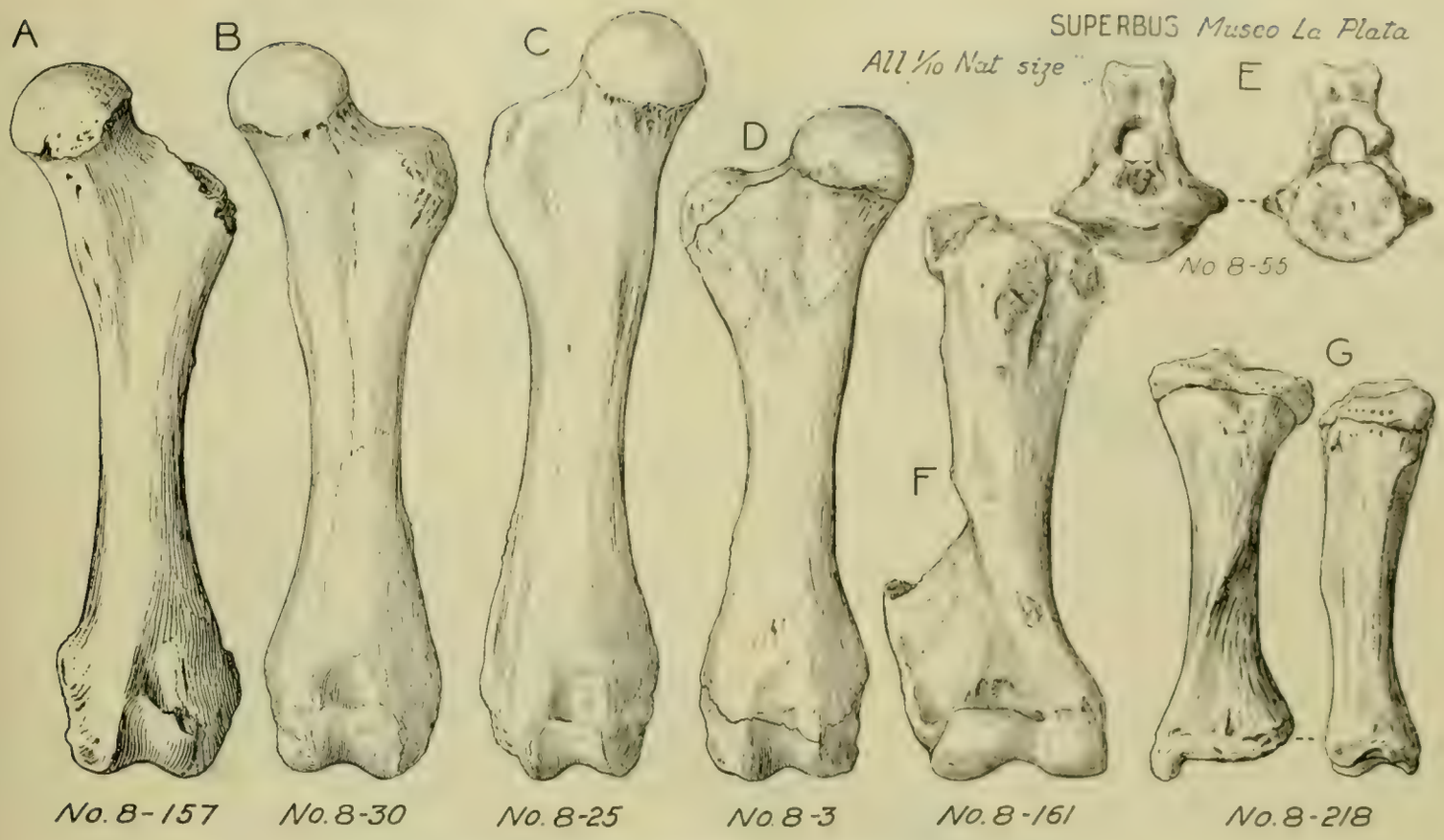


Fig. 565. Skeleton referred to Cuvieronius superbus
Larger, more massive than *Cuvieronius platensis* (Fig. 564). (?)Superior Pampean.
Uniformly reduced to one-tenth natural size. Length estimated from figures.

After Cabrera, 1929, assembled from figures 31 (axis), 32 (humerus), 33, 34 (femora), 35 (tibia) of '*Stegomastodon*' *superbus*.
A, Left femur (Mus. La Plata 8–157), from Carlos Casares, Province of Buenos Aires, Argentina. Length 1020 mm. Fig. 34*a*.
B, Left femur (Mus. La Plata 8–30), from Province of Buenos Aires, Argentina. Length 1055 mm. Fig. 33*b*.
C, Right femur (Mus. La Plata 8–25), from Mercedes, Province of Buenos Aires, Argentina. Length 1110 mm. Fig. 33*a*.
D, Right femur (Mus. La Plata 8–3), from Rio Matanzas, Province of Buenos Aires, Argentina. Length 970 mm. Fig. 34*b*.
E, Axis (Mus. La Plata 8–55), from the "arroyo del Medio." Fig. 31.
F, Right humerus (Mus. La Plata 8–161), from Cañuelas, Province of Buenos Aires, Argentina. Length 800 mm. Fig. 32.
G, Left tibia (Mus. La Plata 8–218), from Salto, Province of Buenos Aires, Argentina. Length 633 mm. Figs. 35*a*, *b*.

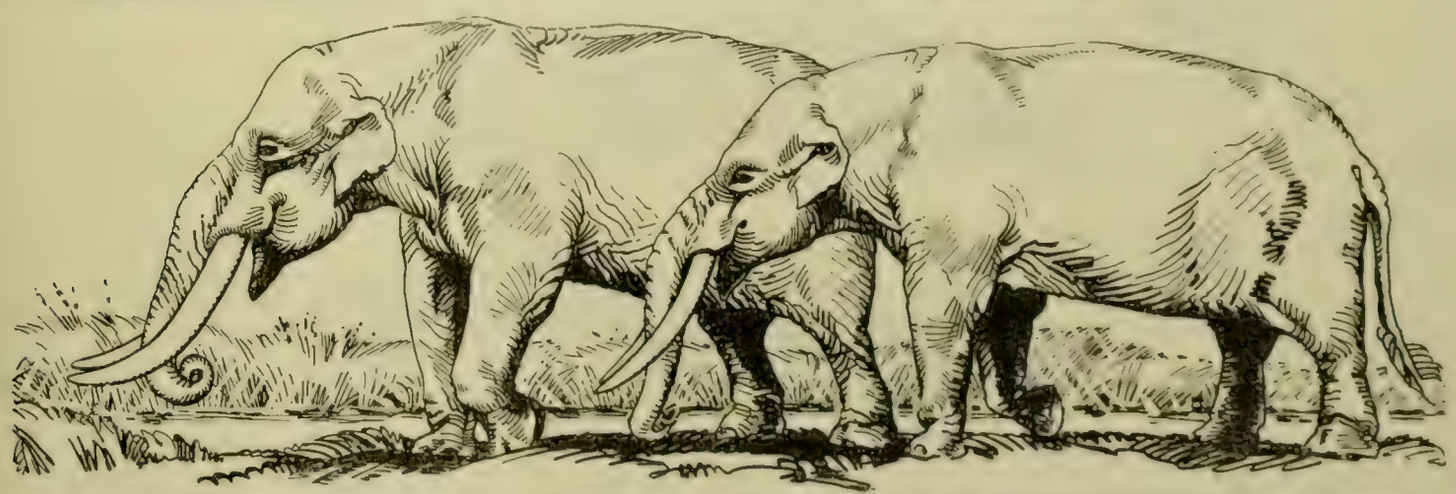
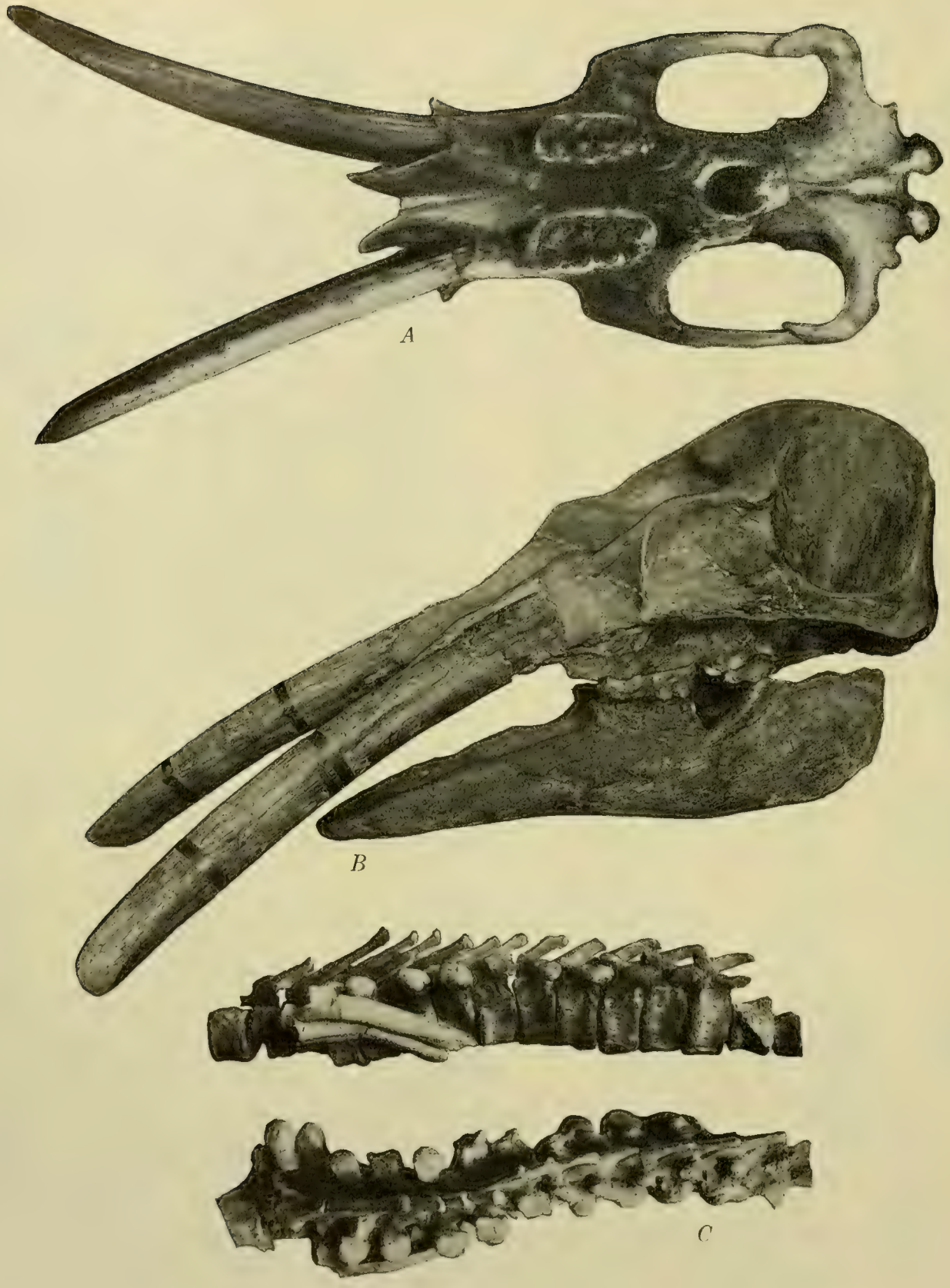


Fig. 566. Cuvieronius superbus (Left) and C. platensis (Right) restored under the Direction of Henry Fairfield Osborn, by Margret Flinsch (1932)
Uniform scale of one-fiftieth natural size

The outlines of the crania and of the limbs rest entirely on the largest of the skeletal remains respectively referred to these two species in the La Plata Museum, as figured in 1929 by Cabrera, namely, *Cuvieronius superbus*, an animal of larger size, and *C. platensis*, an animal of smaller size.



EUBELODON MORRILLI, 'PERFECT TUSKER' OF NORTHERN NEBRASKA

Fig. 567. Type skull and jaws (after reconstruction) of *Eubelodon morrilli* Barbour, 1914 (Neb. Mus. 1–16–5–13); also portion of *referred* upper vertebral column, one-tenth natural size. From Devil's Gulch B, Brown County, Nebraska.

A, Palatal view. After Barbour, 1914.1, Pl. IX. Compare figure 569.

B, Side view of skull and jaws. After photograph by Professor Barbour. Dome of skull restored to white dotted line. Tip of tusk to condyle, 1.703 m. Length of mandible, 1.092 m.

C, Vertebral series *referred* to *E. morrilli* (Neb. Mus. 43–1–11–12). Total length, 1.08 m. After Barbour, 1914.1, Pl. XI.

III. DESCRIPTION OF EUBELODON MORRILLI OF NEBRASKA, WITH RESEMBLANCES OF EUBELODON TO CUVIERONIUS

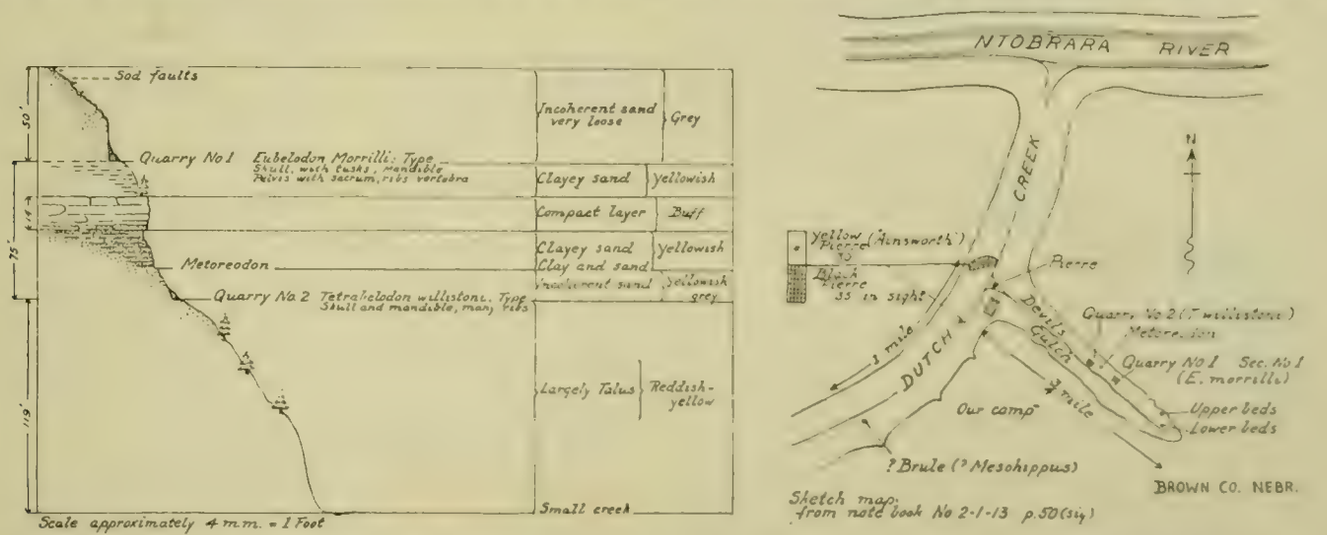
FAMILY: HUMBOLDTIDÆ fam. nov.; GOMPHOTHERIIDÆ Cabrera, 1929
SUBFAMILY: HUMBOLDTINÆ Osborn, 1934

GENUS: **EUBELODON** Barbour, 1914

Original reference: Univ. Neb. Studies, Vol. XIV, pp. 194–197 (Barbour, 1914.1).
Genotypic species: *Eubelodon morrilli* Barbour, 1914.

GENERIC CHARACTERS (BARBOUR, OSBORN).—(1) "No enamel bands on the superior tusks." (2) Simple, rounded, downwardly and outwardly turned superior tusks; no inferior tusks. (3) Double trefoils on the superior and inferior grinding teeth; grinders broad; ridge-crest formula, $M\frac{3}{3}$. (4) Rostrum and inferior mandible elongate, somewhat downturned and pointed, with no trace of alveolus for tusks. (5) Cranial and facial region primitive, subequal. (6) Adaptations chiefly to a browsing habit similar to that of *Trilophodon* and *Tetralophodon*. (7) Differs from *Tetralophodon* in persistent four-crested, brachyodont third inferior grinders. (8) Occipital condyle low compared with elevated condyle and occipital crest of *Cuvieronius superbus*.

The generic name *Eubelodon*, signifying 'well tusked,' implies the affinity of this genus, in the mind of its author, to *Tetrabelodon* (=*Tetralophodon*) and to *Dibelodon* (=*Trilophodon*), in the sense of Cope and Falconer.



LOCALITY SOUTH OF THE NIOBRARA RIVER WHERE THE TYPES OF TRILOPHODON WILLISTONI AND EUBELODON MORRILLI WERE DISCOVERED BY BARBOUR (CF. FIGS. 272 TO 274)

Fig. 568. The Devil's Gulch section, Brown County, Nebraska. After sketches by E. H. Barbour, 1913. This very important section, of a total thickness of 244 feet, rests upon the Fort Pierre Cretaceous (Ainsworth formation) below. It is believed by Professor Barbour to include at the base an Oligocene member (=Brule, *Mesohippus-Oreodon* zone); W. D. Matthew (letter, October 19, 1916) regards these underlying clays as of more recent age than the Oreodon beds, Upper Miocene or Lower Pliocene; the *Mesohippus* of Devil's Gulch may be *Archæohippus*. This region is fortunately associated with a fairly rich fauna containing skulls referred by Barbour to *Alticamelus*, to *Procamelus*, to *Merychippus*, to the rodent *Mylagaulus*, to the referred canid *Cynarctus*, and to the felid (?)*Eusmilus whitfordi*. This is a Lower to Middle Pliocene fauna.

(2) Devil's Gulch B, Lower to Middle Pliocene including Quarry No. 1, contains the type of *Eubelodon morrilli* in which the mandible is tuskless.

(1) Devil's Gulch A, including Quarry No. 2, contains the type of *Tetrabelodon* [=*Trilophodon*] *willistoni;* this type lay in the same bed with a palate referred to (?)*Merychippus;* twenty feet above it the type of *Metoreodon* was discovered; forty-five feet above was a hard compact layer. We conclude that *Trilophodon willistoni* was of Lower Pliocene age. We have no record of the exact level of the type of *Tetrabelodon* [*Trilophodon*] *abeli* Barbour. The above identifications rest chiefly on Barbour's observations.

The very important generic and specific type specimen differs from *Tetralophodon* and *Trilophodon* in the entire absence of lower incisive tusks, yet the rostrum of the lower jaw is quite as elongate as in *Tetralophodon*

campester, for example; the superior and inferior grinders agree with those of *T. campester* in exhibiting double trefoils, but they *differ* from those of *T. campester* in possessing only four transverse ridges, as in *Trilophodon*. Consequently Osborn agrees with Barbour that the type of *Eubelodon morrilli* represents a genus distinct from either *Tetralophodon* or *Trilophodon*. A further distinction from both *Tetralophodon* and *Trilophodon* is the *absence* of an enamel band on the superior tusks.

It is this peculiar combination of characters which suggested to Osborn (1921–1931) the theory that *Eubelodon morrilli* is perhaps related as an ancestral stage to the Notorostrines of South America, and especially to the species grouped under the genus *Cuvieronius*,[1] which are also distinguished by *double* trefoils on the grinding teeth and by the absence of inferior tusks as well as by the absence of an enamel band on the superior tusks.

The unique characters of the type individual (Fig. 567) and type and referred skeletal parts (Fig. 572) from Devil's Gulch, Brown County, Nebraska, are confirmed and amplified (1933) by the superb skull (Fig. 574) discovered near Ainsworth, Nebraska, and described by Childs Frick (1933). The original description of the splendid type specimen by Prof. Erwin H. Barbour is given below.

1. DESCRIPTION OF EUBELODON MORRILLI TYPE, OF NEBRASKA

Eubelodon morrilli Barbour, 1914

Figures 498, 567–577

(?) Middle Pliocene, upper horizon, Devil's Gulch B, Brown County, Nebraska.

HISTORY.—Professor Barbour originally characterized this type specimen as follows (Barbour, 1914.1, p. 194): . . . "From this point, another proboscidean skull and mandible, complete pelvis, ribs, and stray limb bones were secured." His characteristic sketch of the lower jaw is reproduced in figure 570. Osborn's original sketch of the superior and inferior grinding teeth is reproduced in figure 571. As finally restored, the type is shown in figure 567, endorsed by Professor Barbour as Neb. Mus. 1–16–5–13. The fine pelvis (Fig. 572) also bears the same number, namely, Neb. Mus. 1–16–5–13. Referred to the same species are the vertebral series (Fig. 567) bearing the number Neb. Mus. 43–1–11–13, also (Fig. 572) a femur (Neb. Mus. 41–1–11–13), a tibia and fibula (Neb. Mus. 47–1–11–13), and a humerus (Neb. Mus. 39–1–11–13).

Eubelodon morrilli Barbour, 1914. "Mammalian Fossils from Devil's Gulch." Univ. Studies, Univ. Neb., Vol. XIV, No. 2, April, 1914, pp. 194–197. TYPE AND LOCALITY.—"Quarry No. 1 is 75 feet higher up the canyon wall, and about 35 feet below the general level of the surface, perhaps 100 yards to the southeast of Quarry No. 2. From this point, another proboscidean skull and mandible, complete pelvis, ribs, and stray limb bones, were secured. We have named this specimen *Eubelodon morrilli*, in honor of Honorable Charles H. Morrill, a former President of the Board of Regents, and for many years a patron of the Department." Museum, University of Nebraska, No. 1–16–5–13. TYPE FIGURE.—Barbour, *op. cit.*, 1914.1, Pls. IX, X, XI, and XII.

TYPE DESCRIPTION.—(Barbour, 1914.1, pp. 194–197): "This individual is larger in size than the first mentioned [*Tetrabelodon willistoni*], and has marked structural differences. The mandible is destitute of tusks. In some respects, *Eubelodon* seems to be a more primitive form than *Tetrabelodon willistoni*. It is a large, exceptionally long-jawed, low-browed proboscidean. The mandible is fully 43 inches (1,902 [1092] mm.) long, and 20 inches (509 mm). across the condyles, and has but one large tooth in each ramus. The symphysial prolongation is 15½ inches (393 mm.). The lingual groove is shallow, with rounded edges. The skull, as far as it has been worked out is rather flat and long."

"The two [upper] tusks, found in exact position, are finely preserved. They curve downward, slightly outward, and are without enamel bands. The tusks are worn to sharp, chisel-like tips. A section of the tusk near the alveolus is an inverted ovoid 4½ inches (115 mm.) in vertical diameter, and 3½ inches (89 mm.) in horizontal diameter, with a pulp cavity 2¾ (70 mm.) × 1¾ inches (45 mm.)."

"The mandible of *Eubelodon morrilli* constitutes a striking character. It is massive, straight, and of great length, with low ascending rami. In life the [upper] tusks projected scarcely more than a foot and a half beyond the jaw and lip. There are no inferior tusks. The symphysial prolongation is 15½ inches (393 mm.) and is not decurved. The mandible is massive up to the symphysis, where it begins to contract somewhat, then tapers rapidly to the tip. Two grooves, one to the right, and one to the left, parallel the lingual groove, noticeably reducing the bulk of the symphysial portion. . . . In *Eubelodon morrilli*, the end of the long, straight, massive tapering mandible comes well towards the tip of the tusks, thus making an interesting, if not grotesque, facial portion to the skull. It is an unmastodon-like mastodon. The teeth are reduced to one in each jaw, and they measure about 3½ inches (89 mm.) by 8 inches (203 mm.). These teeth have four deeply worn ridges, showing inner and outer trefoiled cones, and a small fifth ridge or heel. Alveolar impressions in the maxillae show where a preceding tooth has been crowded out by a horizontal successor. The ascending rami are low, being at most but 3 inches (77 mm.) above the grinding surface of the molars. They are capped by nearly circular condyles of low convexity, and unlike *Elephas* are without necks. Contrast with this *Elephas imperator*, in which the ascending rami are about 11 inches (280 mm.) above the grinding surface, and that of *Elephas indicus*, which are about 9 inches (230 mm.). The coronoids are on a level with the condyles, and, though somewhat

[1](1935) Referred to the new family Humboldtidæ, subfamily Humboldtinæ Osborn, 1934 (see Appendix to present Volume I).

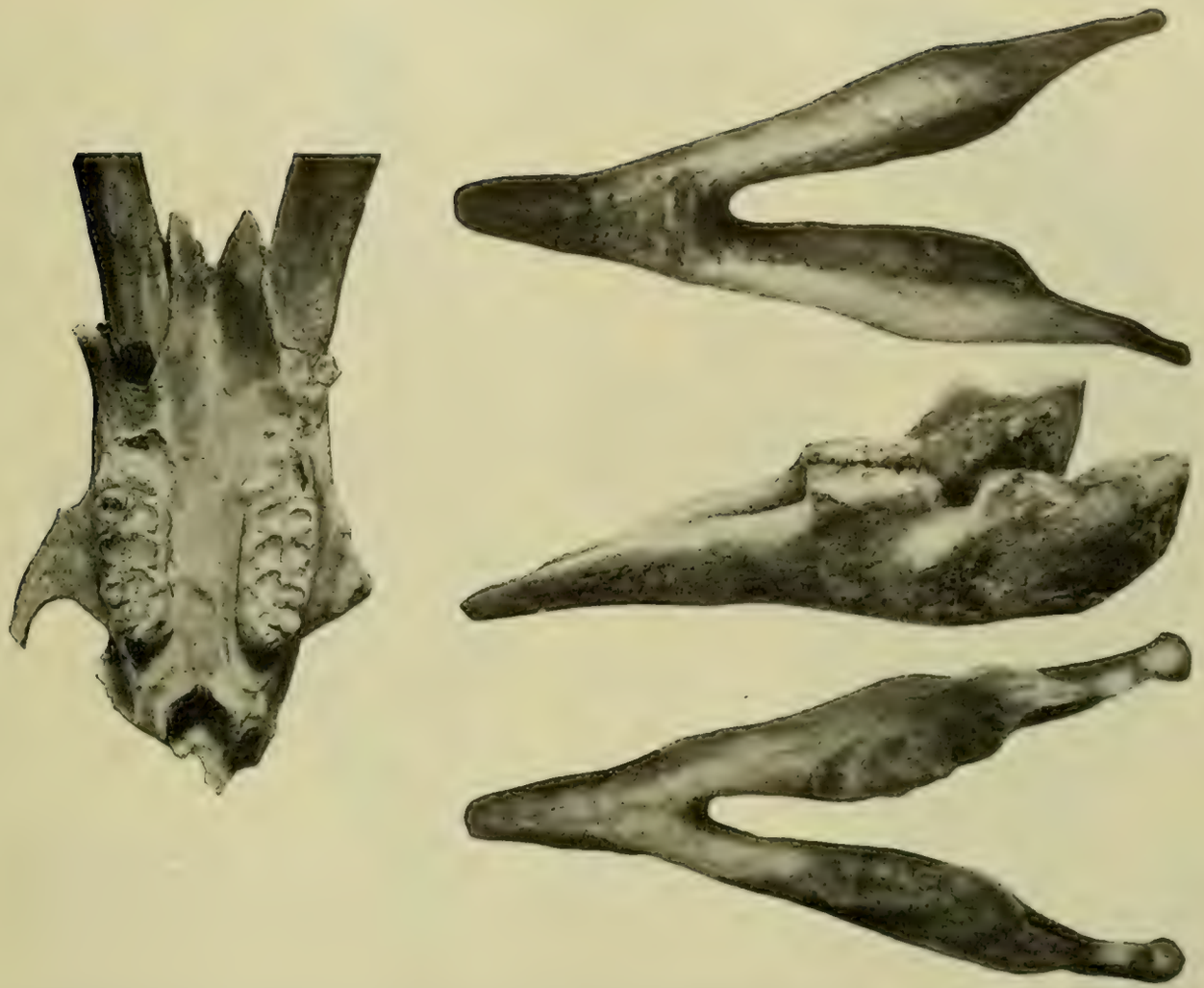


Fig. 569. Type jaws and palate (before reconstruction) of *Eubelodon morrilli* Barbour, 1914 (Neb. Mus. 1–16–5–13), from Devil's Gulch B, Brown County, Nebraska. After photograph by Professor Barbour (cf. Barbour, 1914.1, Pl. x, for three views of mandible). One-tenth natural size.

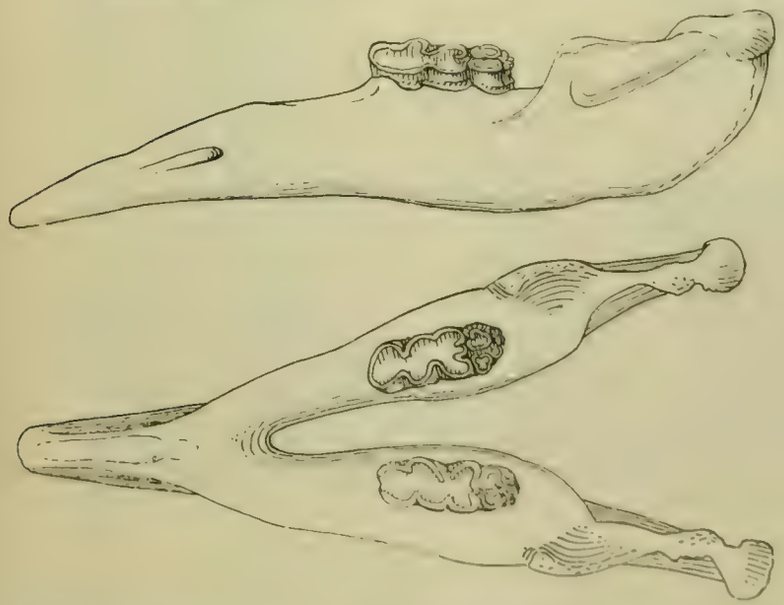


Fig. 570. Figure of type jaw of *Eubelodon morrilli* Barbour (Neb. Mus. 1–16–5–13). After original pen sketch by Barbour. Compare Barbour, 1914.3, p. 217, fig. 3.

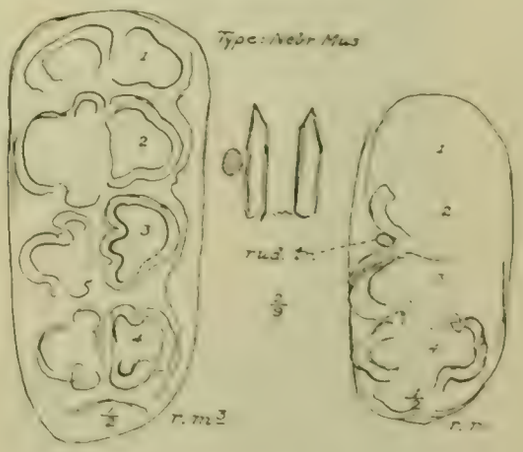


Fig. 571. Crown pattern of third superior and inferior molars, M^3-M_3, type of *Eubelodon morrilli* Barbour (Neb. Mus. 1–16–5–13), showing four crests and double trefoils, also laterally compressed section of superior tusks. Not to same scale. After pencil sketch by Osborn. Type r.M^3, ap. 203 mm., tr. 89 mm., index 44. Referred r.M^3 (F:A.M. 25708), ap. 203 mm., tr. 101 mm., index 50. Type M_3, ap. 202 mm., tr. 90 mm., index 45.

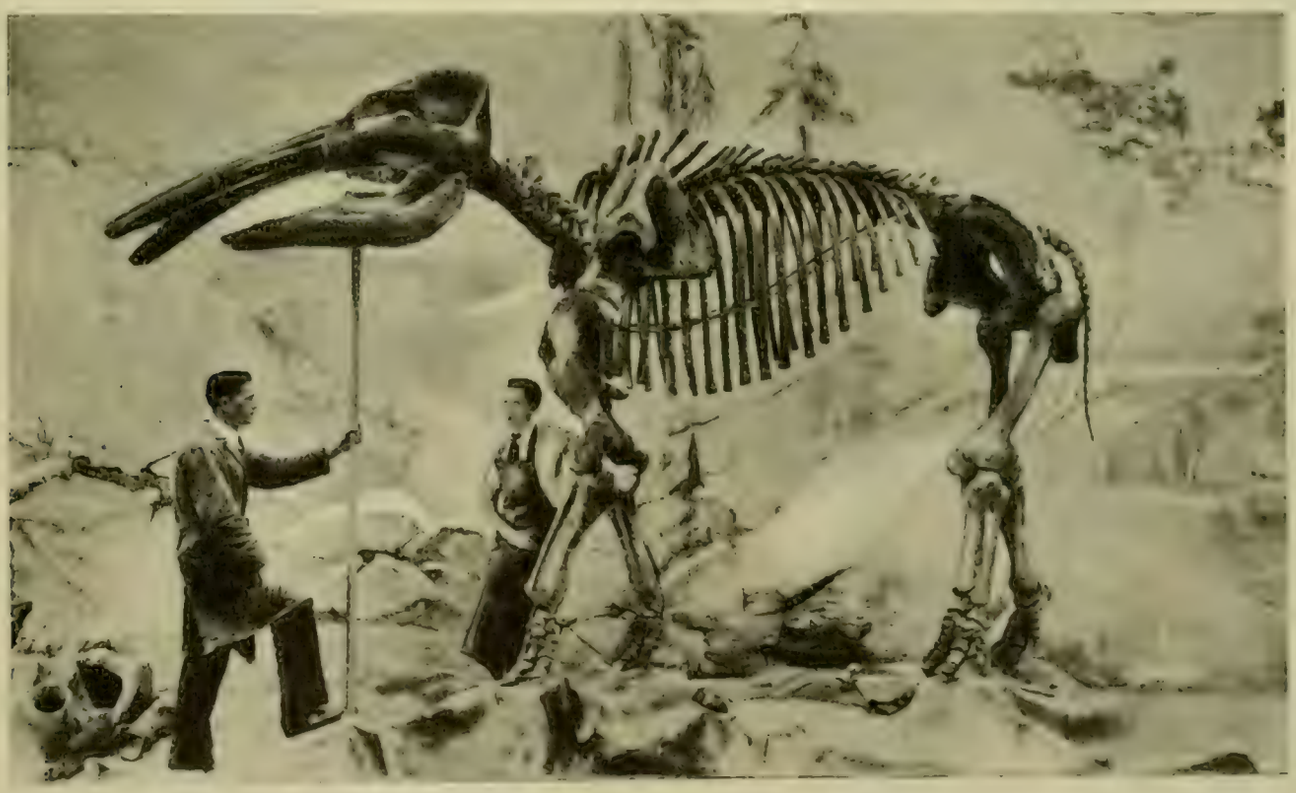
Fig. 572. Type pelvis and referred limb skeleton of *Eubelodon morrilli*, one-tenth natural size. After photographs by Professor Barbour.
A, Type pelvis, posterior and inferior views (Neb. Mus. 1–16–5–13); extreme width, 1424 mm. (cf. Barbour, 1914.1, Pl. XII).
C, Referred femur (Neb. Mus. 41–1–11–13); extreme width, 355 mm. (cf. Barbour, 1914.1, Pl. XIII).
D, Referred tibia and fibula apparently united (Neb. Mus. 47–1–11–13); length of tibia, 560 mm. (cf. Barbour, 1914.1, Pl. XIII).
B, Referred right humerus (Neb. Mus. 39–1–11–13); extreme height, 760 mm. (cf. Barbour, 1914.1, Pl. XIII).

compressed, are thick and strong compared with any fossil or living elephant. The sigmoid notch is very shallow. The inferior mandibular border, which is very broad and round at the molars, narrows and swings by an easy curve into the ascending ramus.

The tusks of *Eubelodon morrilli* are relatively large, but short, distinctly wedge-shaped at the tips, and without enamel bands. Starting at the skull, where the maxillae are just 1 foot (305 mm.) across from outside to outside, the tusks diverge until they are 3 feet (915 mm.) apart at the tips, and curve downward slightly. Each tusk is 4 feet (1,220 mm.) long. One foot of the tusk is firmly imbedded in the jaw, and an additional 6 inches is partly sheathed and buttressed by the maxillae. . . . The pelvis, including sacrum and sacral spine, is perfectly preserved, and indicates an animal of large size. The acetabulum measures 6½ inches (165 mm.) in diameter. The neural arch measures 1½ inches (38 mm.). The pelvic aperture is 16 inches (407 mm.) transversely, by 14 inches (356 mm.) vertically. The thyroid foramen is 7½×4½ inches (192×115 mm.). The extreme width across the ilia is 56 inches (1424 mm.)."

Discussion, Osborn, 1921: (1) This important generic and specific type is exceptional in the absence of lower tusks, which might be regarded as a *female* character of certain Longirostrines, although this point awaits confirmation, since in all Longirostrine jaws hitherto observed the lower tusks are present and obviously were used for feeding purposes. This absence of tusks might be a *variation*. (2) The stage of evolution of this species is indicated by the last superior and inferior grinders, which although much worn, exhibit evidences of trefoils, as shown in the accompanying sketch by Osborn; the upper molars appear to be most progressive; there are indications of cement. (3) In the upper molars the double trefoils are developed on crests 2, 3, and 4; in the lower molars the trefoils are mostly worn away, except the vestige of a trefoil on crest 4, and rudiments of internal trefoils on crests 2, 3, and 4. (4) Both upper and lower molars may be described as four crested, with a talon. (5) As usual, there is a broad internal cingulum on the upper molars. The outer side is more convex, the inner more plane or concave. (6) In the lower molars the cingulum is less distinct, the inner surface is plane, the outer surface is convex. (7) The superior tusks are relatively short, flattened laterally, chisel shaped at the extremities, without enamel band. (8) *Skeletal characters:* Skeleton includes excessively broad pelvis, robust right humerus, proximal portion of femur, and "united" tibia and fibula, as shown in the accompanying figure, rearranged from photographs kindly furnished the present author by Prof. Erwin H. Barbour (compare Barbour, 1914.1, Pls. XII and XIII).

Conclusion, Osborn, 1921.—The apparent abbreviation of the type jaw, the entire absence of inferior tusks, the reduction of the adult grinding dentition to a single molar tooth above and below, the laterally compressed tusks, the presence of four ridges on the third grinders, all tend to exclude *Eubelodon morrilli* from the typical Longirostrines, and to relate it to the Humboldtinæ, such as *Cuvieronius humboldtii*.



Eubelodon morrilli Skeleton as Mounted in the Nebraska State Museum, 1931

After photograph by E. H. Barbour. One thirty-second natural size. Compare Barbour, 1932.1, fig. 152. Background by Elizabeth Dolan

Fig. 573. The type cranium and pelvis (Figs. 567A, B, 572A) are mounted with the referred femur (Fig. 572C), tibia and fibula (D), and humerus (B) In Osborn's judgment the anterior dorsal spines are raised too much above the tip of the scapula, giving the *Eubelodon morrilli* an abnormal shoulder height De detailed measurements, see page 609.

REFERRED CRANIUM AND SUPERIOR DENTITION OF EUBELODON MORRILLI

Redrawn for the present Memoir to a uniform one-tenth scale

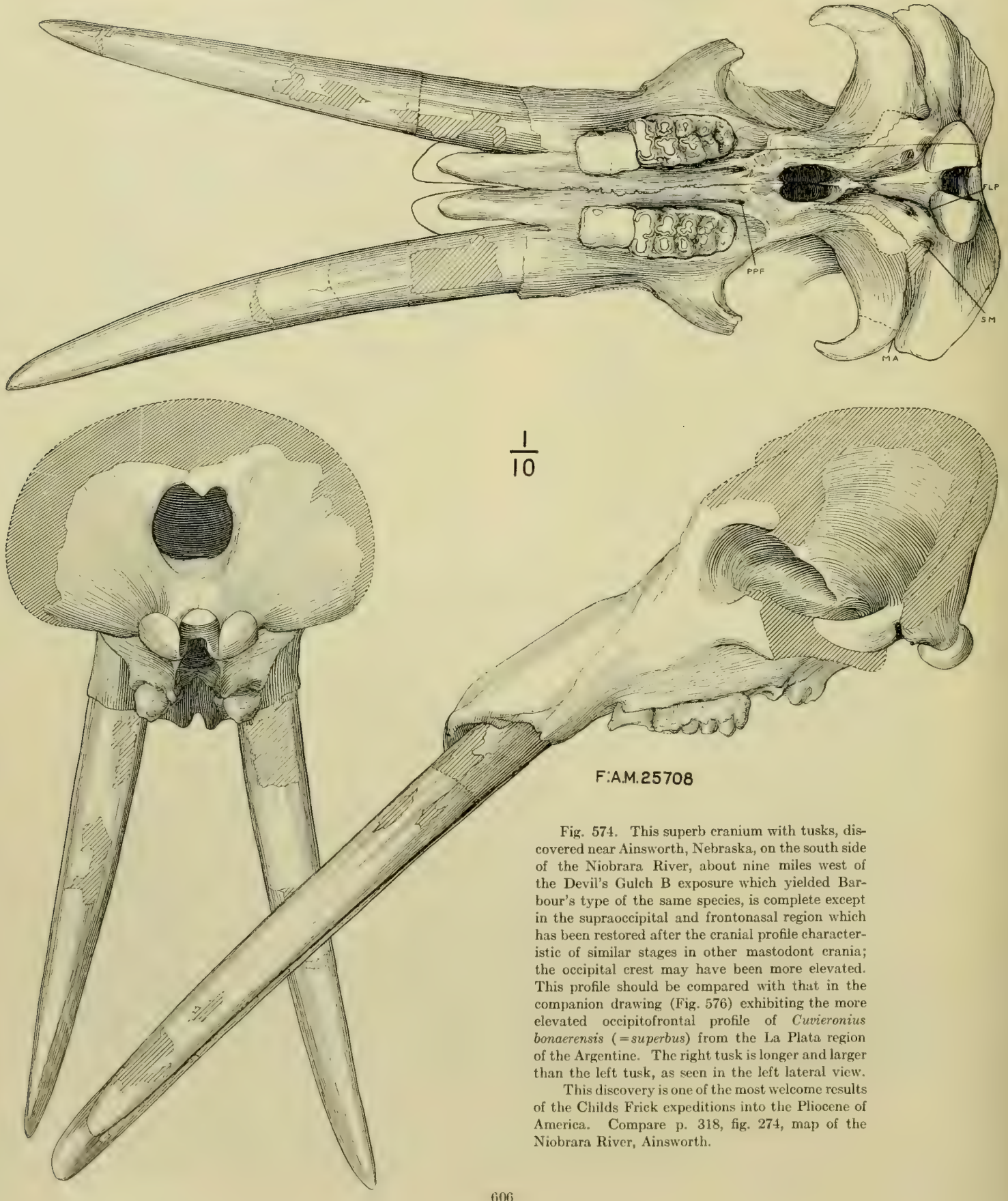


Fig. 574. This superb cranium with tusks, discovered near Ainsworth, Nebraska, on the south side of the Niobrara River, about nine miles west of the Devil's Gulch B exposure which yielded Barbour's type of the same species, is complete except in the supraoccipital and frontonasal region which has been restored after the cranial profile characteristic of similar stages in other mastodont crania; the occipital crest may have been more elevated. This profile should be compared with that in the companion drawing (Fig. 576) exhibiting the more elevated occipitofrontal profile of *Cuvieronius bonaerensis* (=*superbus*) from the La Plata region of the Argentine. The right tusk is longer and larger than the left tusk, as seen in the left lateral view.

This discovery is one of the most welcome results of the Childs Frick expeditions into the Pliocene of America. Compare p. 318, fig. 274, map of the Niobrara River, Ainsworth.

2. REFERRED SKULL AND TUSKS OF EUBELODON MORRILLI, FRICK PLIOCENE COLLECTION

The most welcome discovery in the Frick Collection of 1929 is the skull and portions of the limb skeleton from Horsethief Canyon, near Ainsworth, Brown County, Nebraska; the locality is probably on the same, or slightly above the geologic level as the upper Devil's Gulch B, Quarry No. 1, which yielded the type of *Eubelodon morrilli* Barbour.

Frick (1933, p. 598) rightly refers this skull (Figs. 574, 576) to the rare and relatively little known *Eubelodon morrilli* of Barbour; this fine example affords new, if not decisive, means of determining whether the North American ancestor of the South American '*Mastodon*' *humboldtii* Cuvier has been found. Frick's description (*op. cit.*, p. 598) may be cited in full, as follows:

> BB. 'EUBELODONS' (5) *Eubelodon morrilli* Barbour, 1913. GENOTYPE.—Skull, mandible, etc. Univ. Nebr. Coll. Professor Barbour observes upper tusk to be without enamel, tips chisel-shaped; mandibular symphysis tuskless, contracted laterally anterior to p.s. and with two depressions paralleling the lingual groove; $m\frac{3}{3}$ approximately 203 mm., much worn and furnished with 'double trefoils.' Symphysis length 393 mm., total length of the tusk 1220 mm. Upper tusk without definite enamel band but tendency to variable diffusion of enamel over surface, cross-section round to oval, chisel-shaped at tip, further extruded beyond alveolus and tending less decurved than in typical Longirostrines; $m\frac{3}{3}$ long; inferior incisors missing, symphysial gutter broad, and paralleled by lateral depressions.
>
> [SKULL AND] . . . REFERRED REMAINS. FROM HORSETHIEF CANYON.—Large partial skull with m^2-m^3 and tusks [F:A.M. 25708], and probably associated limb elements (25708A). . . . Figured this paper, *Figs. 12B, 15 and 23B.* Largest of the individuals here listed. Tusks large and after initial flare are unusually straight. $m^2 = 120$ mm. $m^3 = 203$.
>
> [ASSOCIATED LIMB ELEMENTS].—Two humeri, 1 femur, scapula, 2 ilia, etc. vertebræ and ribs. F:A.M. 25708A. Ulna, and atlas, 24.8 cm. F:A.M. 25708C.

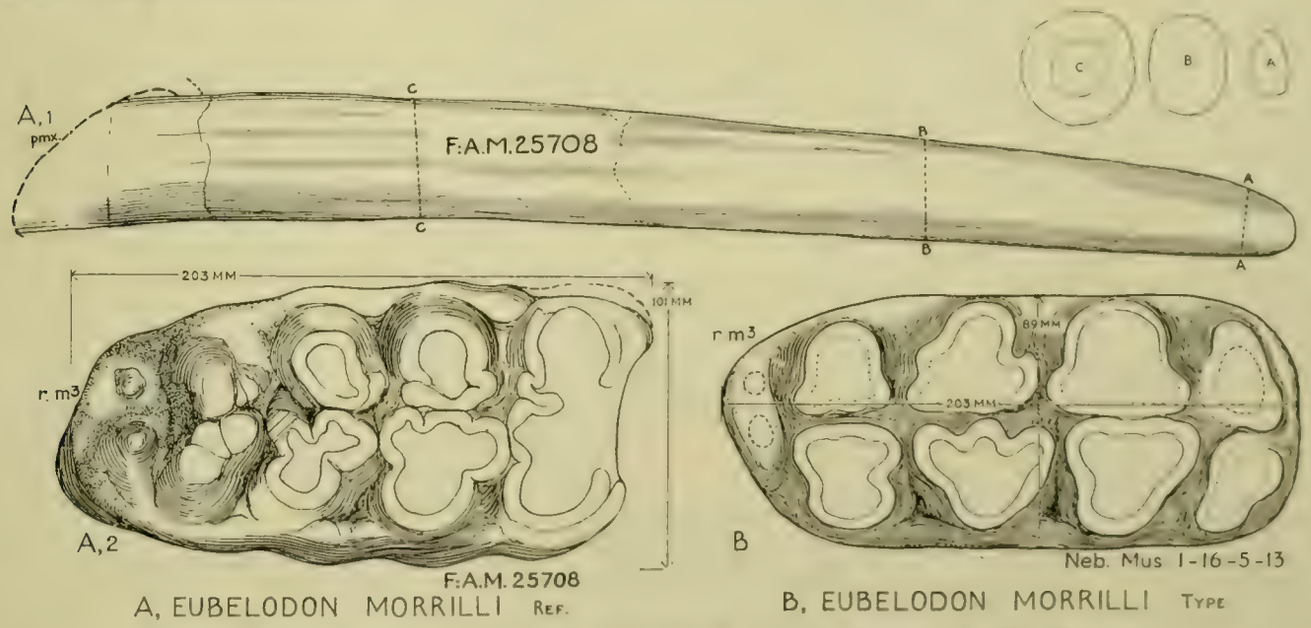


Fig. 575. REFERRED TUSK AND TYPE AND REFERRED MOLARS OF EUBELODON MORRILLI BARBOUR

Neb. Mus. 1–16–5–13: Type of *Eubelodon morrilli* Barbour, inserted for comparison.

B, Type third right superior molar, r.M^3, length 203 mm., breadth 89 mm., index 44.

F:A.M. 25708: Frick Collection, referred *Eubelodon morrilli* Barbour.

A1, Right superior tusk and sections, about one-eighth natural size. Length beyond alveolus 1340 mm. After Frick, 1933, fig. 15.

A2, Third right superior molar, r.M^3, two-fifths natural size. Length 203 mm., breadth 101 mm., index 50. After Frick, 1933, fig. 23B.

SUPERIOR MOLARS.—In the *type* the second grinders are shed and the third grinders (Fig. 575, B) are almost completely worn down, whereas in Frick's referred specimen the second superior molars are still *in situ* while the third molars (Fig. 575, A2) are in a comparatively fresh and unworn condition beautifully displaying the coronal pattern of $4\frac{1}{2}$ ridge-crests with double trefoils, at once reminding us of Cuvier's type of '*Mastodon*' *humboldtii*.

The entotrefoils on the proto- to tetartolophs are somewhat less strongly developed in Frick's specimen (Fig. 575, A2) than in Barbour's type (Fig. 575, B) which in trefoil evolution is slightly more progressive; the pentaloph is represented in both the type (B) and the referred (A2) grinders by two prominent cones.

Tusks. Observe (Fig. 574) that the left incisive tusk (1230 mm. from alveolar border to tip) is slightly shorter than the right (1340 mm. from alveolar border to tip); there is a very slight downcurvature or deflection of both tusks, as displayed also in figure 575, A1 (right superior tusk, external aspect), which reveals the rounded section (C ——C), deeper section (B——B), and terminal flattened section (A——A). The tusks are divergent, as seen both in palatal and in posterior aspect.

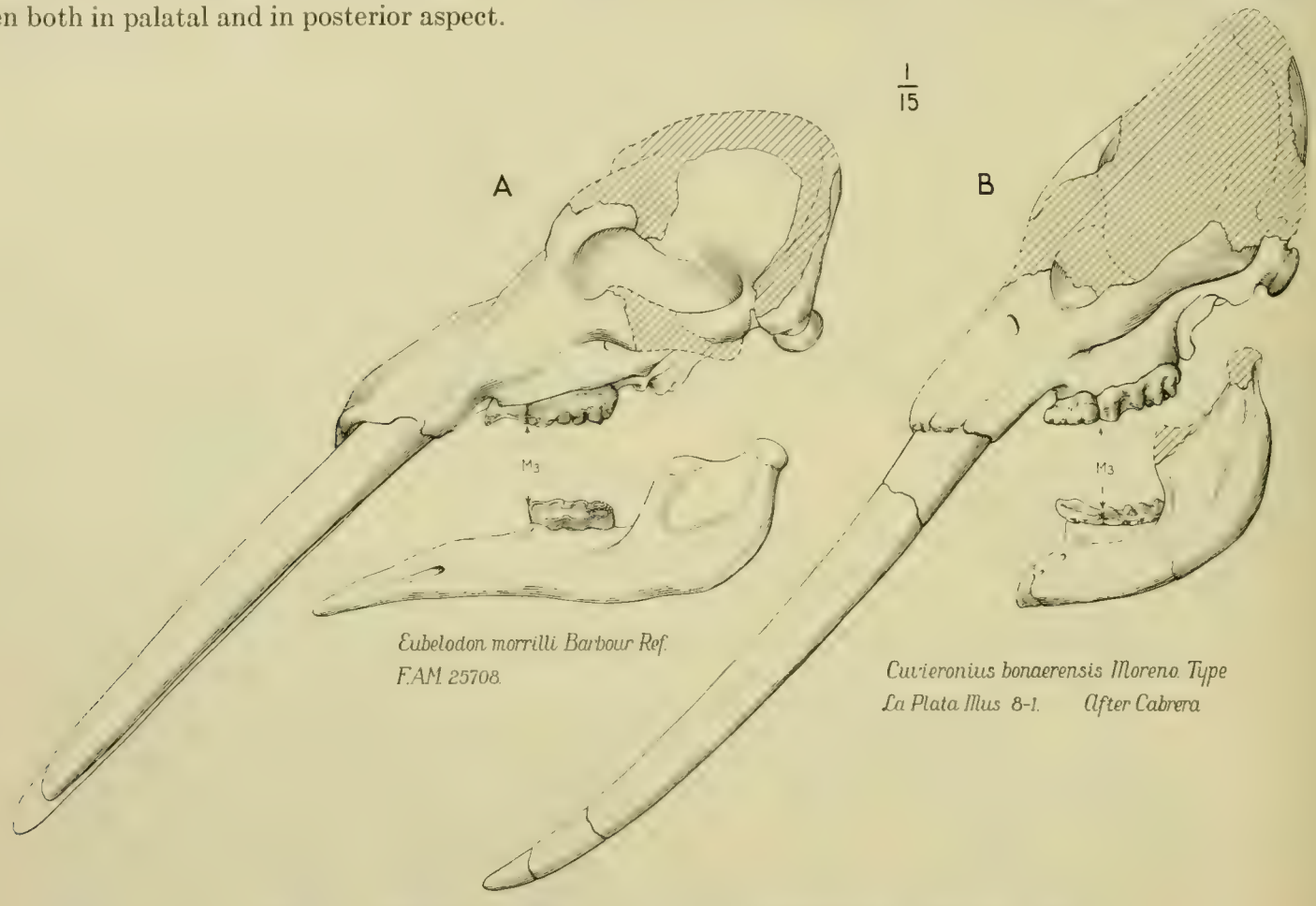


Fig. 576. Comparison of Eubelodon (A) and of Cuvieronius (B) Crania and Jaws
One-fifteenth natural size

A, Newly discovered cranium of *Eubelodon morrilli* ref., Frick Collection in the American Museum 25708. The mandible is drawn in from Barbour's type specimen (Neb. Mus. 1-16-5-13). Compare figures 567 and 569. This cranium is probably long faced (dolichopic), platycephalic, with elongated but edentulous inferior rostrum.

B, *Cuvieronius bonaerensis* Moreno type cranium and jaws (Mus. La Plata 8-1). Molars with 4½ ridge-crests resembling those of *C. superbus* Amegh. This cranium is relatively bathycephalic and acrocephalic, with depressed and abbreviated rostrum both of the cranium and mandible. [=*Cuvieronius bonaerensis* (*superbus*) of the present Memoir.]

From Frick's observations, the posterior palatine foramina (PPF), the stylomastoid foramen (SM), the foramen lacerum posterius (FLP), and the closing auditory meatus (MA) are precisely indicated. The choanæ are relatively narrow and posterior in position, as compared with *Elephas indicus* (see figures in Volume II, Chap. XIV).

Both the Barbour and Frick crania of *Eubelodon morrilli* represent males and the table of comparative measurements below indicates that the younger Frick skeleton is one-eighth larger throughout. Both are inferior in height and in massive width to the Warren Mastodon (*Mastodon americanus*) in the American Museum (Fig. 124).

COMPARATIVE MEASUREMENTS OF THE BARBOUR AND FRICK SKELETONS OF EUBELODON MORRILLI

	Type Neb. Mus. 1–16–5–13 *fide* Barbour	Ref. F:A.M.25708 *fide* Frick
Cranial length, condyle to maxillary tips		1120 mm.
Palatal length, postnarial openings to maxillary tips		730
Cranial width across glenoid processes		720
Length (1120 mm.)—breadth (790 mm.) index of cranium, estimated		71
Width across zygomatic arches, maximum breadth, estimated		730
Breadth of occipital condyle		250
Height of occiput, estimated		350
Vertical diameter of right tusk at point c——c		125
Length of exposed portion of tusk	776	1230–1340
Length of mandible	1092	
Third inferior molar:		
anteroposterior	202	
transverse	90	
breadth-length index	45	
Third superior molar:		
anteroposterior	203	203
maximum width	89	101
breadth-length index	44	50
Second superior molar:		
anteroposterior		120
Pelvis, width across ilia	1424	
length, crest to ischium	1040	

Referred Skeletal Measurements, Type Locality

	Ref. Neb. Mus. 39–1–11–13	Ref. F:A.M. 25708A
Humerus:		
length	760 mm.	910 mm.
distal diameter	215	
Scapula, height	760	880
Radius, length	610*	
Ulno-radius, transverse	230	
Ulna, length	685	660
Femur:		
height	940	1080
distal diameter	230***	
Tibia, length	560****	
Fibula, length	545	
Forelimb:		
scapula to ground	2390	
humerus to ground	1625	
hindquarters, pelvis rim to ground	2260	
head of femur to ground	1830	
Atlas, type:		
transverse		390e**

Type and Referred Skeleton as Mounted

	Type Neb. Mus. 1–16–5–13		
Total length of skeleton, tip of tusks to tip of tail	5260	17 ft. 7	in.
Maximum length, exclusive of tail:			
tip end of tusk to extremity of ischium	4410	14 ft. 5½	in.
tip end of jaw	3930	12 10¾	
Height:			
anterior dorsal spines to base	2370	7 9¼	
tip of scapula to base	2440	8	
summit of ilium to base	2290	7 6¼	
summit of occiput to base	2850	9 4¼	

*Measurement from Neb. Mus. 3–9–16.
**Measurement from F:A.M. 25708C.
***Measurement from Neb. Mus. 15–6–20.
****Measurement from Neb. Mus. 47–1–11–13.

Nebraska State Museum Skeleton of Eubelodon morrilli Barbour

For comparison the measurements of the type and referred skeleton of *Eubelodon morrilli*, as mounted in the Nebraska State Museum, and those of the Warren Mastodon in the American Museum, are as follows:

	Eubelodon morrilli	*Mastodon americanus* Warren Mastodon
Humerus (right side, ref.), extreme length	910 mm.	950 mm. (rt.)
Pelvis, extreme width of iliac bones	1424 mm.	1826 mm.
Femur, length of	1080 mm.	1060 mm. (rt.)
Tibia, length of	560 mm.	710 mm. (rt.)
Summit of scapula from the ground	2440 mm.	2635 mm.

Colbert (1933) makes the following observations regarding the Frick skeleton from Horsethief Canyon (F:A.M. 25708): A very large specimen, showing many characters typical of *Eubelodon*. The skull is rather long and low, and is very broad at the glenoids. Characteristic features are strong pterygoids and very restricted opening for the posterior nares. Third superior molars, M^3, 4½ ridge-crests; outer trefoils (ectotrefoils) of M^3 very faint. The tusks are large and round in cross-section; without enamel.

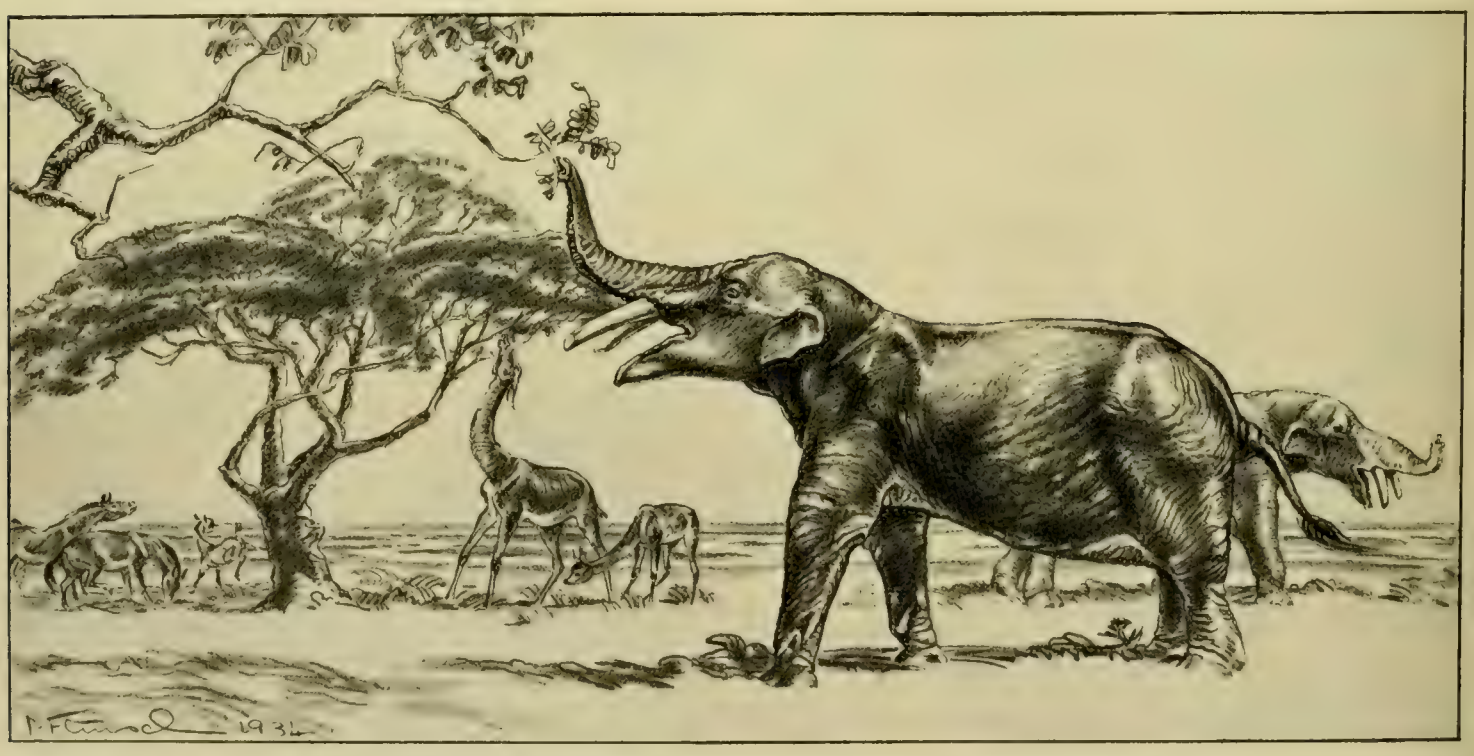


Fig. 577. Eubelodon morrilli, the Humboldtine Mastodont of Western Nebraska
Restoration (1934) by Margret Flinsch, under the direction of Henry Fairfield Osborn
One-fiftieth natural size

This restoration is directly after the mounted skeleton in the Nebraska State Museum shown in figure 573 above. The anterior portion of the body is lowered between the scapulæ bringing the anterior border of the scapulæ about at the level of the summit of the vertebral spine. The head is raised in the act of browsing. The rostrum of the lower jaw is without tusks. In the distance are groups of *Alticamelus* (center) and of *Pliohippus* (left).

RESEMBLANCES OF EUBELODON TO CUVIERONIUS IN CRANIUM AND DENTITION

Of surpassing interest and significance is the comparison of the *Eubelodon* and *Cuvieronius* crania, as shown in the accompanying figure (Fig. 576) especially prepared to a uniform one-fifteenth scale from the most recent profile drawing of the left side of *Eubelodon morrilli* after Frick and Osborn (Fig. 574) and after original drawing of *Cuvieronius bonaerensis* (=*superbus*) kindly loaned by Doctor Cabrera. Fortunately we are able to present the palatal aspect of *Cuvieronius* for comparison.

In lateral aspect, the crania and tusks are seen to be substantially the same in size. In the cranium: (1) The more progressive *Cuvieronius bonaerensis* is distinguished by the marked elevation of the occipital condyle, which, in harmony with progressive hypsicephaly, is well elevated above the occlusion or attrition line of the grinding teeth, in contrast to the relatively primitive depressed occipital condyle of *Eubelodon morrilli*, which is only 560 mm. above the occlusion level of the grinders; (2) observe also the sharply elevated apex of the occipitofrontal crest in *C. bonaerensis*, in contrast to the relatively low, rounded crest as restored in *E. morrilli*.

Both these cranial adaptations are coördinated with the respective down- or upcurvature and function of the tusks in *Eubelodon* and *Cuvieronius*, as follows: (1) In *Eubelodon* the tusks are very slightly downcurved, conserving the primitive downcurvature of the paired superior incisors of all primitive mastodonts. Yet this downcurvature is extremely slight and the tusks might be described as nearly straight, as in those of the type of *Cuvieronius rectus* (Fig. 490). (2) On the contrary, the tusks of *C. bonaerensis* are moderately upcurved, as shown in the present figure (Fig. 576), see also figure 562 above; this upcurvature is in mechanical correlation with the uplifting, uprooting function of the tusks and the elevated occipitofrontal crest.

Grinding Teeth.—(1) The double trefoiled superior grinders of *Eubelodon morrilli* (Figs. 574, 575) exhibit very strong entotrefoils with more rudimentary or incipient ectotrefoils. (2) Similarly the grinder referred to *Cuvieronius rectus* (Fig. 546), of Inferior Pampean age, also presents large entotrefoils while the ectotrefoils are much smaller. (3) This referred molar of *C. rectus* measures 204e mm. × 102 mm., in comparison with 203 mm. × 101 mm. in the referred *E. morrilli* (F:A.M. 25708) and with 203 mm. × 89 mm. in the type (Neb. Mus. 1–16–5–13). (4) Ameghino and Boule define (p. 530 of the present Memoir) '*Mastodon*' *platensis* as exhibiting grinders with single trefoils. (5) Consequently we make the important observation that there existed in the Inferior Pampean of Argentina a grinding tooth (Fig. 546) of the same size and quite as primitive as that of *Eubelodon morrilli* of Nebraska. (6) In the Inferior Pampean also is found a straight tusk, the type of *Cuvieronius rectus*, which resembles the straight tusk of *Eubelodon morrilli*.

Ancestral Relationships.—Putting together the important resemblances between specimens of *Eubelodon morrilli* of Nebraska and the relatively little-known primitive remains of tusks and grinding teeth from the Inferior Pampean of Argentina, we reach the very important conclusion that *E. morrilli* is a Middle Pliocene ancestral stage in the subfamily Humboldtinæ on its way from Eurasia through North America to South America. In the Andean region there appear the primitive short-limbed forms *Cuvieronius ayoræ* and *C. postremus*, and the primitive typical *C. humboldtii* of Bolivia, (?) Ecuador, and Chile, quadrupeds of smaller size and possibly of mountain habitat.

Possibly a direct descendant of *Eubelodon* is the straight-tusked *Cuvieronius rectus* of the Inferior Pampean of the Argentine.

Finally there appears in the Pampean the giant *Cuvieronius superbus* and the more specialized *C. platensis* as distinguished by Cabrera.

It is obvious that the South American Humboldtinæ require very careful monographic comparison and revision in connection with which the present revision may serve a useful purpose. The author's views (1934) as to classification are expressed in the synopsis (IV) below. For final classification (1935) see Appendix to the present Volume I.

IV. SYNOPSIS (1934) OF THE NOTOROSTRINE AND HUMBOLDTINE MASTODONTS OF SOUTH AND NORTH AMERICA

The subfamily term NOTOROSTRINÆ is now restricted to the *'Mastodon' andium* group of Cuvier. The new subfamily term HUMBOLDTINÆ embraces both the large *'Mastodon' humboldtii* group and the more highly specialized *Stegomastodon mirificus* group, as displayed in the following synopsis (p. 615). It has recently been determined (Osborn, 1933) that none of the true Brevirostrine mastodonts of Eurasia (*Anancus, Pentalophodon Synconolophus*) migrated into America.

The *Stegomastodon mirificus* group, which Osborn until recently classed with the BREVIROSTRINES of Eurasia, now proves to be closely related in its molar-tooth structure to one division of the NOTOROSTRINES (e.g., the *Cuvieronius humboldtii* group of the new subfamily HUMBOLDTINÆ Osborn, 1934). This observation, first made by Cabrera (1929), is now confirmed by Osborn in a recent very close comparison of the fundamental grinding-tooth pattern in *Stegomastodon.* Both the superior and inferior ridge-crests of the true Brevirostrines of Eurasia are proverted, whereas in the Humboldtines of America the inferior ridge-crests are proverted and the superior ridge-crests are either retroverted or transverse (*Cuvieronius*) or centroverted (*Stegomastodon*). These characters

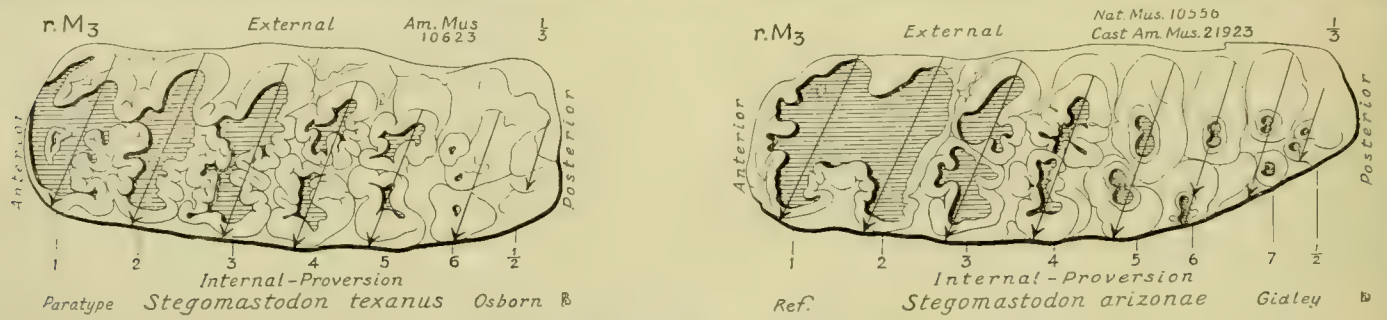


Fig. 578. HUMBOLDTINÆ: PROVERSION OF THE INFERIOR RIDGE-CRESTS IN STEGOMASTODON

Proverted and folded or ptychoid 6½ inferior ridge-crests in *Stegomastodon texanus.*

Proverted and folded or ptychoid 7½ ridge-crests in *Stegomastodon arizonæ.*

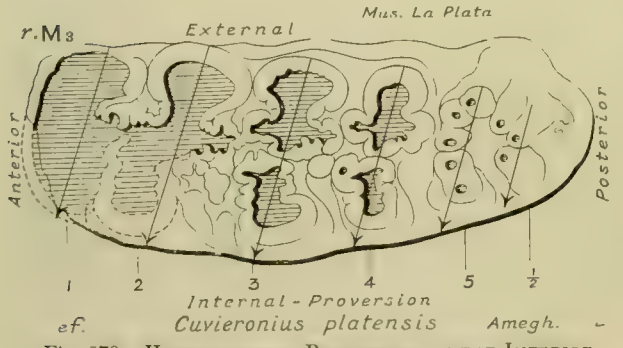


Fig. 579. HUMBOLDTINÆ: PROVERSION OF THE INFERIOR RIDGE-CRESTS IN CUVIERONIUS

Proverted and folded or ptychoid 5½ inferior ridge-crests in *Cuvieronius platensis.* An l.M3 (Mus. La Plata 8-18) reversed, about one-fourth natural size.

are clearly shown in the molar tooth diagrams (Figs. 578–580) which close the present Chapter XII and appropriately (Fig. 581) introduce Chapter XIII.

The *'Mastodon' humboldtii* subfamily HUMBOLDTINÆ suggests analogy with the Brevirostrinæ (including *Anancus*), as indicated by Cabrera in grouping all the *'M.' humboldtii* species within the subfamily Anancinæ under the genus *Stegomastodon*, but, as shown in Section II, 6, it is impossible to derive the more primitive members of the *'M.' humboldtii* group from any of the well-known species of *Stegomastodon* of Texas, all of which, in the Pliocene stage, are extremely progressive in the ridge-crests of their grinding teeth, the ridge formula rising from 5½–6+ (*Stegomastodon mirificus*) to 7½ (*S. arizonæ*). This reasoning is reinforced by the very recent discovery of *'Bunolophodon'*

postremus in the high mountains of Ecuador, in which the grinding teeth with single trefoils are far more simple than those of *S. mirificus* of Nebraska. The resemblances between the *inferior* molars (Figs. 579, 578) of the *'M.' humboldtii* group and the true *Stegomastodon* represent a community of descent.

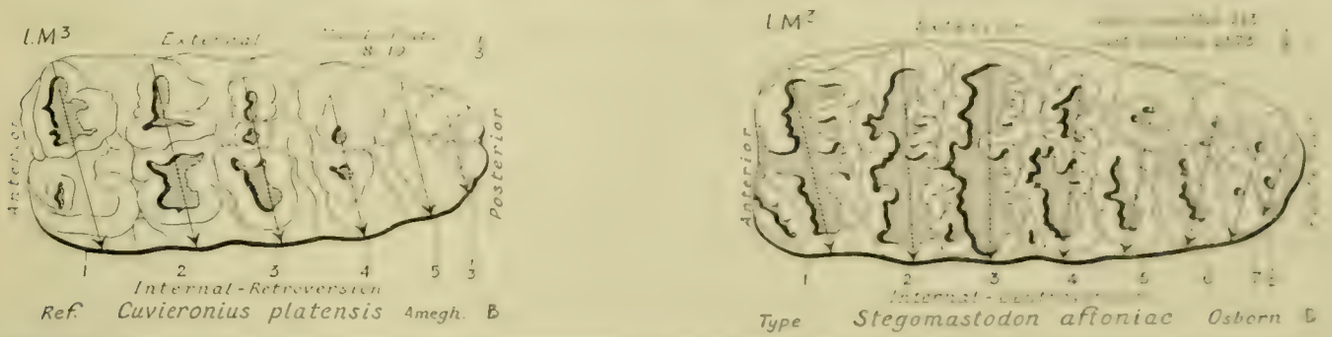


Fig. 580. HUMBOLDTINÆ: RETROVERSION AND CENTROVERSION OF THE SUPERIOR RIDGE-CRESTS IN CUVIERONIUS AND STEGOMASTODON

Internal retroversion in 5+ ridge-crested third superior molar of *Cuvieronius platensis*.

Internal retroversion and centroversion in 7½ ridge-crested third left superior molar of *Stegomastodon aftoniæ*.

On page 537 above is given the order of discovery and description of thirty of the South and North American species of mastodonts. It becomes obvious, after nearly thirty years of study, that they represent three great subfamilies or lines of descent rather than one. These three lines of descent are clearly separated

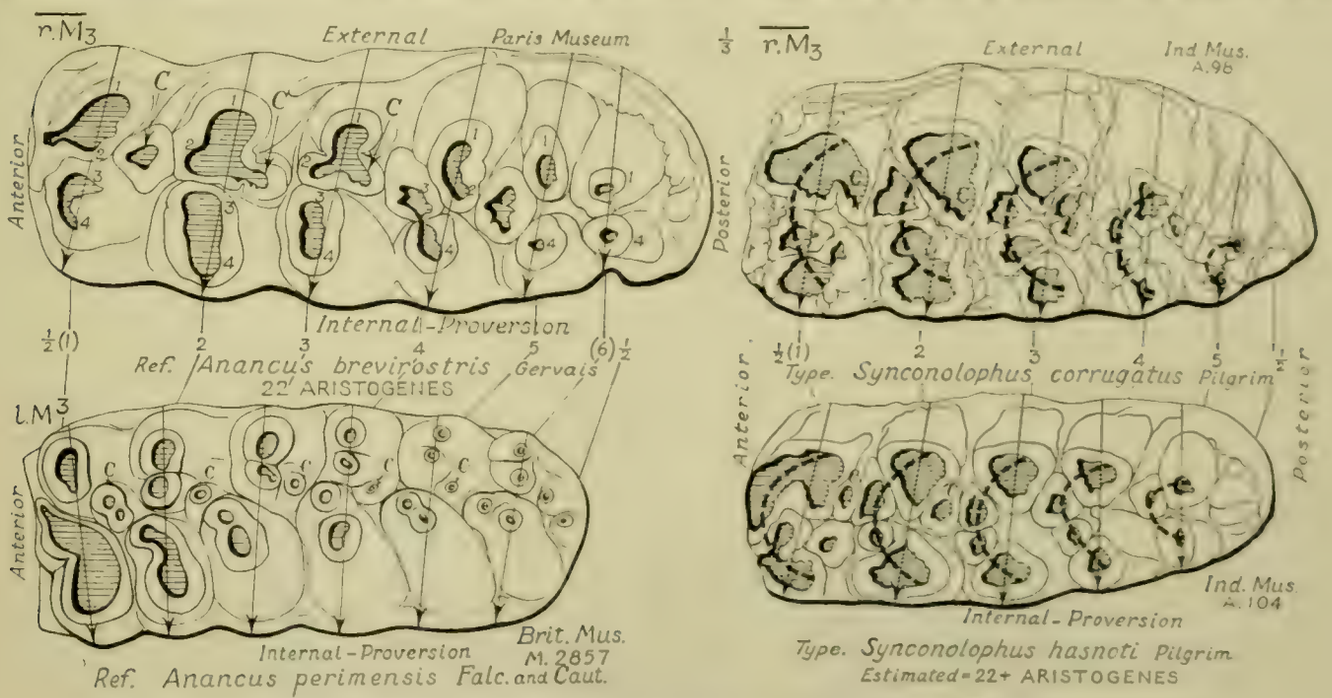


Fig. 581. BREVIROSTRINAE: PROVERSION OF RIDGE-CRESTS IN ANANCUS AND SYNCONOLOPHUS. FOUR CONELETS ON EACH CREST (1, 2, 3, 4); CENTRAL CONULES (CCC) BETWEEN THE CRESTS

(Left upper) *Anancus brevirostris* ref. Third right inferior molar, r.M_3, strong internal proversion of 5½ ridge-crests.
(Left lower) *Anancus perimensis* ref. Third left superior molar, l.M^3, internal proversion of 5½ ridge-crests.
(Right upper) *Synconolophus corrugatus* type. Third right inferior molar, r.M_3, proversion and compaction of 5½ ridge-crests.
(Right lower) *Synconolophus hasnoti* type. Third right inferior molar, r.M_3, proversion and compaction of 5½ ridge-crests.

by the profoundly different characters of (a) the incisive tusks, (b) the proportions of the cranium, (c) the fundamental molar structure. These divergent characters were undoubtedly correlated with different feeding habits and geographic distribution, and since the subfamily name Notorostrinae was first applied to the *'Mastodon' andium* group, with persistent enamel band on the downturned, horizontal, or spiral tusks and relatively simple

enamel foldings of the grinding teeth, the new subfamily name HUMBOLDTINÆ was applied (Osborn, 1934.924, 1934.926) to the '*Mastodon*' *humboldtii* group, without trace of enamel on the upcurved, rounded-oval tusks and with progressive, elaborate foldings of the enamel of the grinding teeth.

COMPARISON OF THE HUMBOLDTINÆ AND BREVIROSTRINÆ

HUMBOLDTINÆ (*Cuvieronius*, *Stegomastodon*)	BREVIROSTRINÆ (*Anancus*, *Synconolophus*)
Internal *proversion* of inferior ridge-crests.	Internal *proversion* of inferior ridge-crests.
Superior ridge-crests *retroverted*, *transverse* (*Cuvieronius*) or *centroverted* (*Stegomastodon*).	Superior ridge-crests internally *proverted* (*Anancus*, *Synconolophus*).
Ridge-crests increased from 5½ to 7½.	Ridge-crests arrested at 5½.
Ptychoid infoldings of enamel into double or quadruple trefoils. Cones, conelets, and trefoils.	Number of aristogenes arrested at 22+; cones and conelets relatively simple (*Anancus*), compressed and internally ptychoid (*Synconolophus*).

These comparisons between the fundamental grinding-tooth pattern of the superior and inferior molars in the HUMBOLDTINÆ of America and the BREVIROSTRINÆ of Eurasia demonstrate that the abbreviation of the inferior mandible in *Stegomastodon* is a matter of *convergence* rather than of parallelism. The true Brevirostrinæ are confined to Eurasia and are treated in the succeeding Chapter XIII under the generic terms *Anancus*, *Pentalophodon*, and *Synconolophus*.

The present Chapter XII on the South American Mastodonts is continued and completed at the close of Chapter XIII in the description and discussion of the seven[1] species of *Stegomastodon* which have been discovered in North America. While embraced within the subfamily HUMBOLDTINÆ, it will be shown that *Stegomastodon* is clearly distinguishable generically from *Cuvieronius*.

Notiomastodon, while treated in this chapter, is found (1934) to be a new member of the Serridentinæ,[2] as demonstrated by its molar pattern in the accompanying figure.

With these distinctions the known thirty-six[3] South and North American species of Notorostrinæ and Humboldtinæ may be *provisionally* regrouped (1934) as shown on the following page 615.

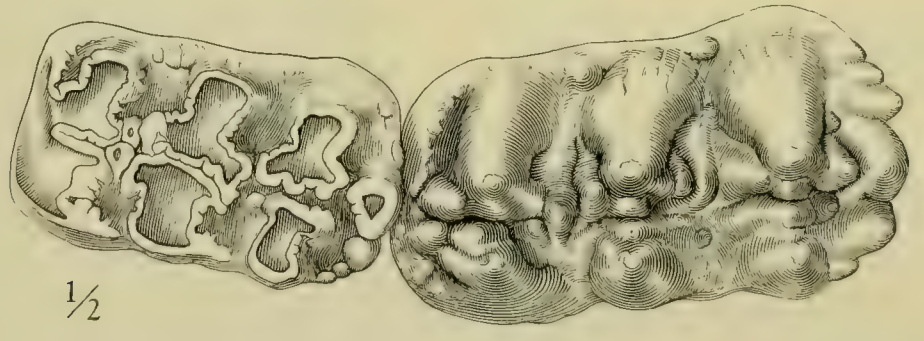


Fig. 581a. Type first and second inferior molars of the right side, r.M_{1-2}, of *Notiomastodon ornatus* Cabrera, 1929, redrawn for the present Memoir. One-half natural size. See Appendix to the present Volume I, Pl. XII, for mandible (lateral and surface views).

[1]The eighth species, *Stegomastodon primitivus* sp. nov., is described in the Appendix to the present Volume I.
[2]In the Appendix to the present Volume I, *Notiomastodon* is made the type of the new subfamily Notiomastodontinæ, of the new family Serridentidæ.
[3]Thirty-five, as *Stegomastodon primitivus* sp. nov. is not included in this list.

Subfam. 1. **NOTOROSTRINÆ** Osborn, 1921, "embracing the classic species '*M.*' *andium*, '*M.*' *humboldtii*," etc., restricted (1934) to *Cordillerion andium* and related species. Superior tusks with enamel band, spiral or downturned. Cranium primitive, rostrum elongate.

I. **Cordillerion andium** and related species. Superior tusks sub-spiral, with broad enamel band following the curve; molars narrow, ridge-crest enamel simple with single trefoils, not folded or ptychoid. Chiefly of browsing habit and mountain-loving habitat.

1) *Cordillerion andium* Cuvier, Quito, Ecuador. Pleistocene
2) *Cordillerion bolivianus* Philippi, Ulloma, Bolivia
3) *Cordillerion tarijensis* Ameghino, Valley of Tarija, Bolivia
4) *Cordillerion gratum* Hay, Burleson County, Texas
5) *Cordillerion edensis* Frick, San Bernardino County, California
6) *Cordillerion tropicus* Cope, Mexico.
7) *Cordillerion oligobunis* Cope, Mexico.
8) *Cordillerion oligobunis antiquissimus* Freudenberg, Valley of Amajaque, Mexico
9) *Cordillerion*(?) *oligobunis felicis* Freudenberg, Puebla, Mexico
10) *Cordillerion*(?) *oligobunis intermedius* Freudenberg, Mexico
11) *Cordillerion oligobunis progressus* Freudenberg, Cannada de Aculcingo, Mexico
12) *Cordillerion orarius* Hay, Sinton, San Patricio County, Texas
13) *Cordillerion defloccatus* Hay, Sinton, San Patricio County, Texas
14) *Cordillerion bensonensis* Gidley, near Benson, Cochise County, Arizona
15) *Cordillerion andium kraglievichii* Berro, Uruguay

Subfam. 2. **SERRIDENTINÆ** Osborn, 1921

II. **Notiomastodon ornatus**[1] and related species. Superior tusks non-spiral, outwardly and downwardly curved, with broad external enamel band; inferior molars with large external and rudimentary internal trefoils (*fide* Cabrera), enamel partly folded, ptychoid, transverse. Lower Pleistocene.

1) *Notiomastodon ornatus* Cabrera. Superior tusks relatively short and obtuse, sharply downcurved
2) *Notiomastodon argentinus* Ameghino. Superior tusks long and slender, gently downcurved

Subfam. 3. **HUMBOLDTINÆ** Osborn, 1934 (see p. 575 above). Typified by '*Mastodon*' *humboldtii* Cuvier. Superior tusks rounded or suboval, up- and incurved or straight without trace of an enamel band. Molars relatively broad with double trefoils, large infero-external and supero-internal, double trefoils more or less fully developed; enamel coarse, progressively ptychoid to chœroid; ridge-crests M 3, 4½–5½ (Figs. 560, 561). *Proversion* of inferior molar ridge-crests. Chiefly of browsing and grazing habit and plains- or plateau-loving habitat.

I. **Cuvieronius humboldtii** and related species. Tusks elongate; molars with single to double trefoils. Inferior ridge-crests *proverted;* superior ridge-crests *transverse* or *retroverted.* Limbs elongate, body relatively short and high.

1) *Cuvieronius humboldtii* Cuv., Concepcion, Chile, genotypic species
2) *Cuvieronius brasiliensis* Lund (in Lesson), Velhas River, Province of Minas Geraes, Brazil
3) *Cuvieronius platensis* Ameghino, Buenos Aires, Argentina. Middle or Lower(?) Pampean
4) *Cuvieronius superbus* Ameghino, Buenos Aires, Argentina. Upper(?) Pampean
5) *Cuvieronius bonaerensis* (=*superbus*) Moreno, Buenos Aires, Argentina
6) *Cuvieronius rectus* Ameghino, La Ensenada, near La Plata, Argentina, Lower(?) Pampean
7) *Cuvieronius maderianus* Ameghino, Buenos Aires, Argentina
8) *Cuvieronius chilensis* Philippi, Lake Tagua-Tagua, Chile
9) *Cuvieronius pirayuiensis* Gez, near Corrientes on the Paraná River, northern Argentina

II. **Cuvieronius.** Molars with single trefoils, enamel relatively simple; tusks short, robust, upturned. Limbs relatively short; trunk relatively elongate. Chiefly of browsing habit and plateau-loving habitat.

1) *Cuvieronius postremus* Spillmann, near Alangasi, Ecuador. Known from cranium, mandible, and complete skeleton. Molars with 5½ ridge-crests. Upper Pleistocene, pre-Columbian.
2) *Cuvieronius ayoræ* Spillmann, near Punin, Province of Chimborazo, Ecuador. Known from cranium and jaw; also nearly complete skeleton; molars with 5½ ridge-crests.

III. **Eubelodon morrilli** Barbour, Niobrara River, Nebraska. Superior tusks elongate, rounded, downwardly and outwardly turned, without enamel band, molars broad, with double trefoils, ridge-crests M 3, 4½; mandibular rostrum elongate, pointed. Cranium less elevated than in *Cuvieronius humboldtii.*

IV. **Stegomastodon mirificus** and related species. Tusks abbreviate, upturned; molars with double to multiple trefoils inferior ridge-crests *proverted*, superior ridge-crests *centroverted;* M 3, 5½-7½.

1) *Stegomastodon mirificus* Leidy, Nebraska, genotypic species
2) *Stegomastodon chapmani* Hays, Nebraska
3) *Stegomastodon successor* Cope, Texas
4) *Stegomastodon texanus* Osborn, Texas
5) *Stegomastodon arizonæ* Gidley, Arizona
6) *Stegomastodon aftoniæ* Osborn, Iowa
7) *Stegomastodon priestleyi* Hay and Cook, Oklahoma

[1]Made the type of the new subfamily Notiomastodontinæ (see Appendix to the present Volume I).

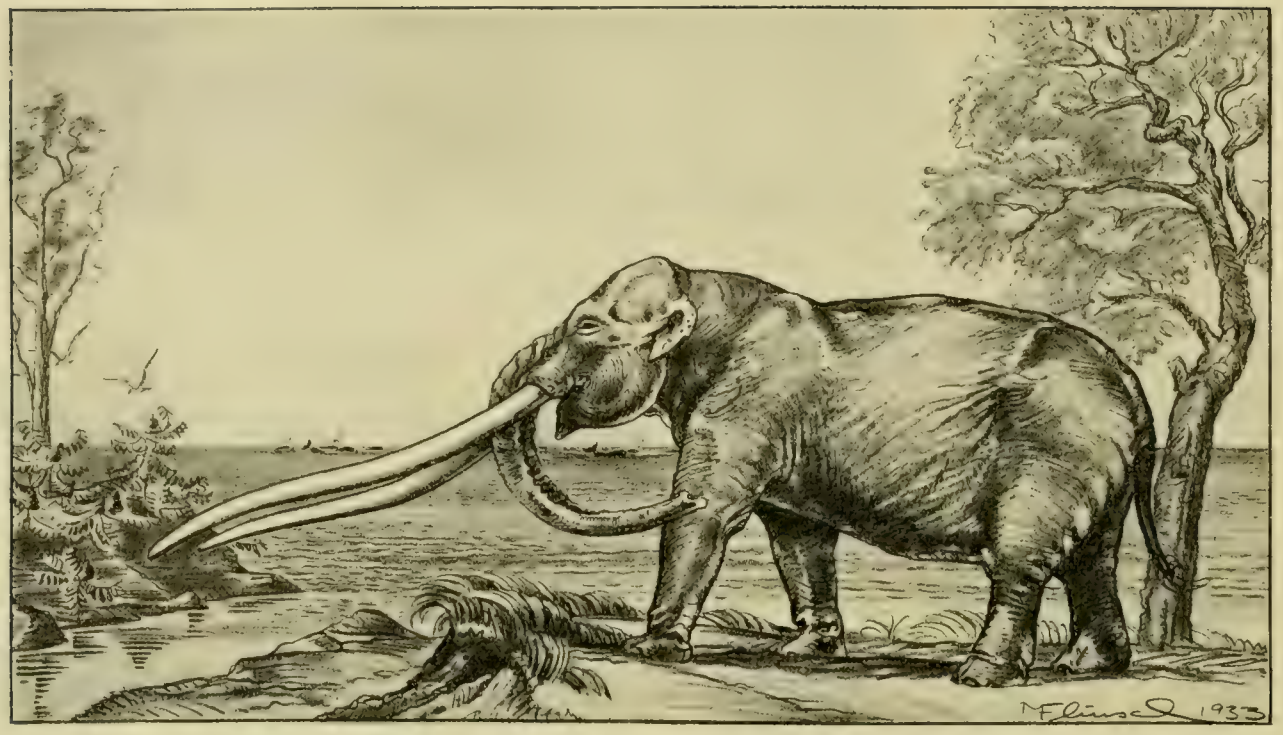


Fig. 582. Anancus arvernensis, the Straight-tusked Mastodont of Auvergne, Southern France, and of Northern Italy
Drawn to a one-fiftieth scale, under the direction of the author, by Margret Flinsch (1933)

Restoration chiefly after mounted skeleton in the Royal University of Bologna (Fig. 585). The size and other data on which the skeleton is based are determined not only from the skeleton in the Bologna Museum, but from the nearly entire skeleton (Fig. 584) discovered at Dusino, near Asti in Piedmont, now deposited in the Turin Museum, also from the unmounted skeleton in the Florence Museum, discovered in the lower Val d'Arno in a marine stratum, along with the skeleton of a whale. The well established height of this animal at the shoulder is 2550 mm., or 8 ft. $4\frac{3}{8}$ in.

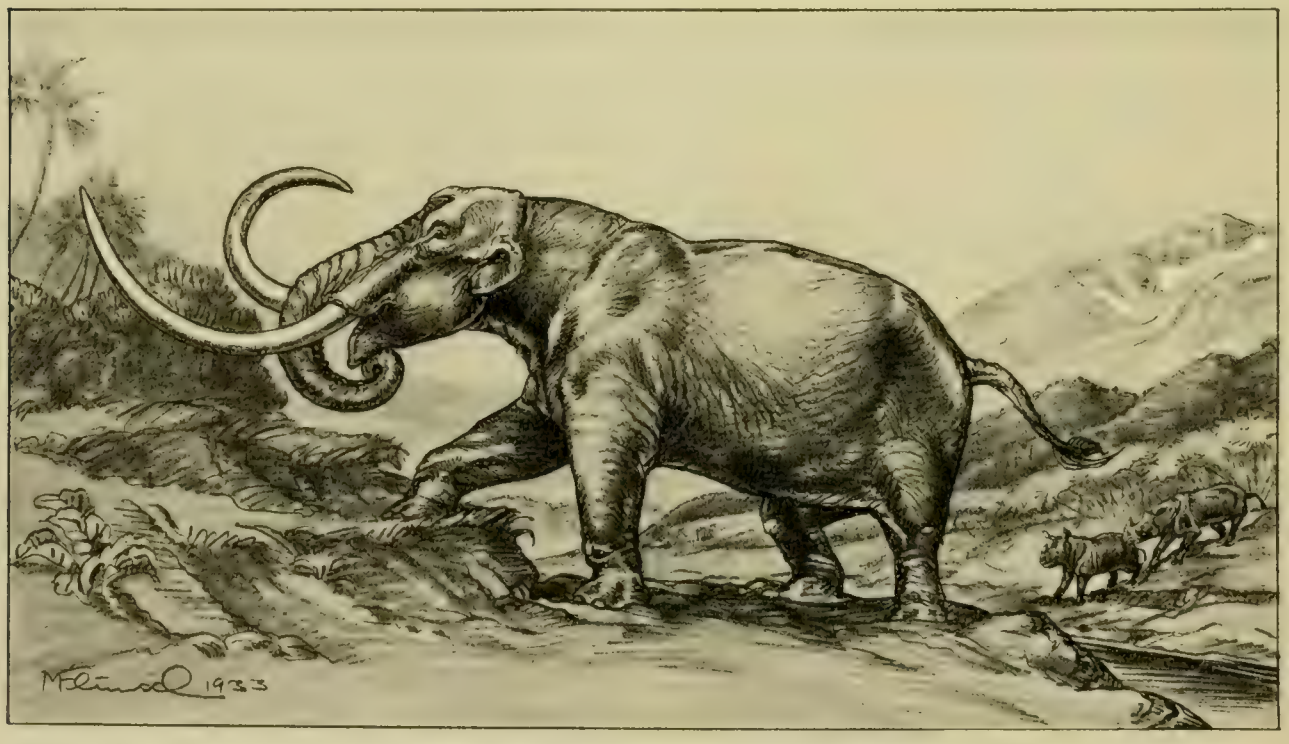


Fig. 583. Synconolophus dhokpathanensis, Middle Pliocene Mastodont of Dhok Pathan in the Foothills of the Himalayas, Salt Range, Northern India
Drawn to a one-fiftieth scale, under the direction of the author, by Margret Flinsch (1933)

This restoration is based solely on the superb type skull and tusks discovered by Barnum Brown in 1922. The locality is three miles west of Dhok Pathan, 500 feet below the top of the Middle Siwaliks; in the same horizon is found the single-horned *Rhinoceros palæindicus* Falc., believed to be ancestral to the existing single-horned Indian rhinoceros. The estimated height of *S. dhokpathanensis* at the shoulder is 2642 mm., or 8 ft. 8 in.

Chapter XIII

THE SUBFAMILY BREVIROSTRINÆ OF EUROPE AND ASIA. GENERA ANANCUS, PENTALOPHODON, AND SYNCONOLOPHUS. STEGOMASTODON OF THE SUBFAMILY HUMBOLDTINÆ IN NORTH AMERICA

Brevirostrinæ: Description of 'mastodon' arvernensis from the Auvergne, France, by Croizet and Jobert in 1828. Asiatic species described by Eichwald and Cautley, 1831–1836; nineteen[1] Eurasiatic species described since 1828.

Humboldtinæ: Description of 'mastodon' chapmani from the ancient territory of Nebraska in 1834. Ascription of eight American species to the genus Stegomastodon.[1]

I. Historical Introduction.
1. Early history (Cuvier, William Smith). Discoveries in France and in England.
2. Discoveries in eastern Europe and in Asia (Eichwald, Falconer, Khomenko, Pilgrim, Brown, 1831–1922).
3. Discovery and description of Humboldtinæ (*Stegomastodon*) and of Notorostrinæ (*Cordillerion*) in North America (1834–1930).
4. Synopsis of the nineteen species of the Brevirostrinæ thus far discovered in France, England, Russia, India, and China; also of the eight Humboldtinæ discovered in Nebraska, Texas, Arizona, Iowa, and Oklahoma.

II. Characters of the Subfamily Brevirostrinæ and Included Genera.
1. Definition of the three genera *Anancus*, *Pentalophodon*, and *Synconolophus*.
2. History and definition of the genus *Anancus*.
3. Characters and geologic distribution of the species of *Anancus*.
4. Distinctions of *Anancus arvernensis* and the more progressive *A. falconeri*.
5. *Anancus arvernensis* or *A. falconeri* in Italy; *Anancus* in Germany.
6. *Anancus* in Hungary, in Volhynia and Bessarabia, Russia, and in China.
7. Crania of the Brevirostrine mastodonts of Eurasia.

III. Succession of the Brevirostrines in India.
1. Characters of the genus *Pentalophodon* Falconer, 1857, 1865.
2. The Upper Pliocene *Pentalophodon sivalensis* Cautley, dentition.
3. The Miocene and Middle Pliocene *Synconolophus*; characters of the genus and of four species.

IV. The Humboldtines of North America.
1. Characters of the genus *Stegomastodon* Pohlig.
2. Characters of the species *Stegomastodon chapmani* Hays, 1834–1843, and of *S. mirificus* Leidy, 1858.
3. Recently discovered Humboldtines of the southwest, *Stegomastodon successor*, *S. texanus*, and *S. arizonæ*. Skeletal characters of *Stegomastodon arizonæ*.
4. The Pleistocene Humboldtine *Stegomastodon aftoniæ* Osborn, 1924, the more ancient *S. priestleyi* Hay and Cook, 1930, also the new species *Stegomastodon primitivus*.

(November, 1934). The North American genus *Stegomastodon*, including seven species ranging from Nebraska to Texas, as fully described in the present Chapter XIII, is now removed from the Brevirostrinæ of Eurasia and placed among the South American mastodonts, of the subfamily Humboldtinæ, because of a fundamental resemblance of the grinding teeth to those of '*Mastodon*' *humboldtii* as shown in the diagrams (Figs. 578-581) at the close of the preceding Chapter XII. See also Appendix to the present Volume I for description of the new species *Stegomastodon primitivus*.

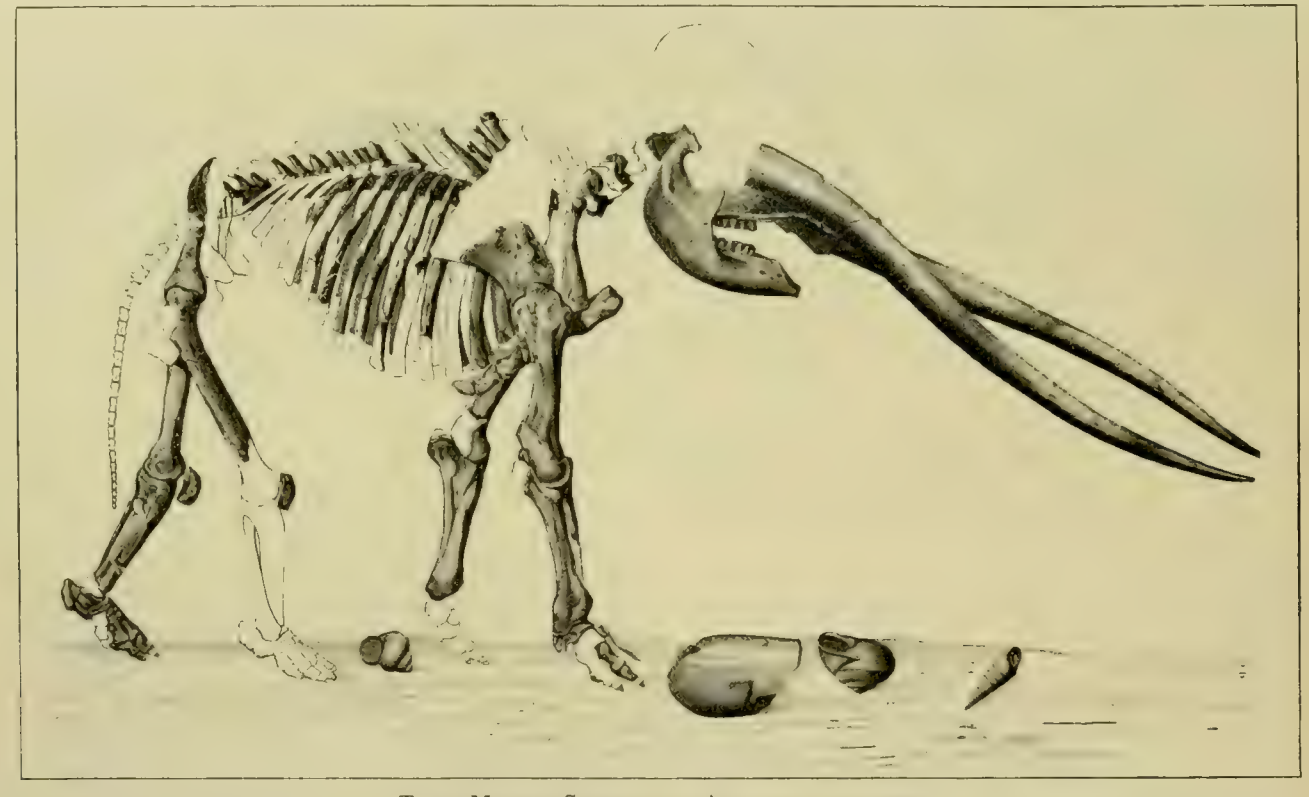
I. HISTORICAL INTRODUCTION

The subfamily name Brevirostrinæ Osborn, 1918, is derived from the name *Mastodon brevirostre* applied by Gervais and de Serres in 1846 to a short-jawed specimen found in the Upper Pliocene of Montpellier. These authors in assigning the name '*brevirostre*' were obviously impressed with the extreme abbreviation of the jaw, in contrast to the extreme elongation of the jaw in the '*Mastodon*' *angustidens* of Cuvier.

[1]See list of species on page 625 below.

1. EARLY HISTORY (CUVIER, WILLIAM SMITH). DISCOVERIES IN FRANCE AND IN ENGLAND

(1) The first mention of the Brevirostrines in France was by Cuvier (1806.3; 1812, II, Chap. XI, Pl. 1, fig. 3) in figuring a tooth among other specimens which he selected as belonging to *Mastodon angustidens*. (2) The *Mastodon arvernensis* of Croizet and Jobert was first described as such in 1828 from Puy-de-Dôme, Auvergne, France; but according to Depéret (1890, p. 62) in his description of the Middle Pliocene fluvio-lacustrine beds of Roussillon, which contained a fauna very similar to that of Montpellier, the type specimen of *M. arvernensis* had been known for two years. (3) From the fluvio-marine sands of Montpellier, Gervais and de Serres described a similar animal

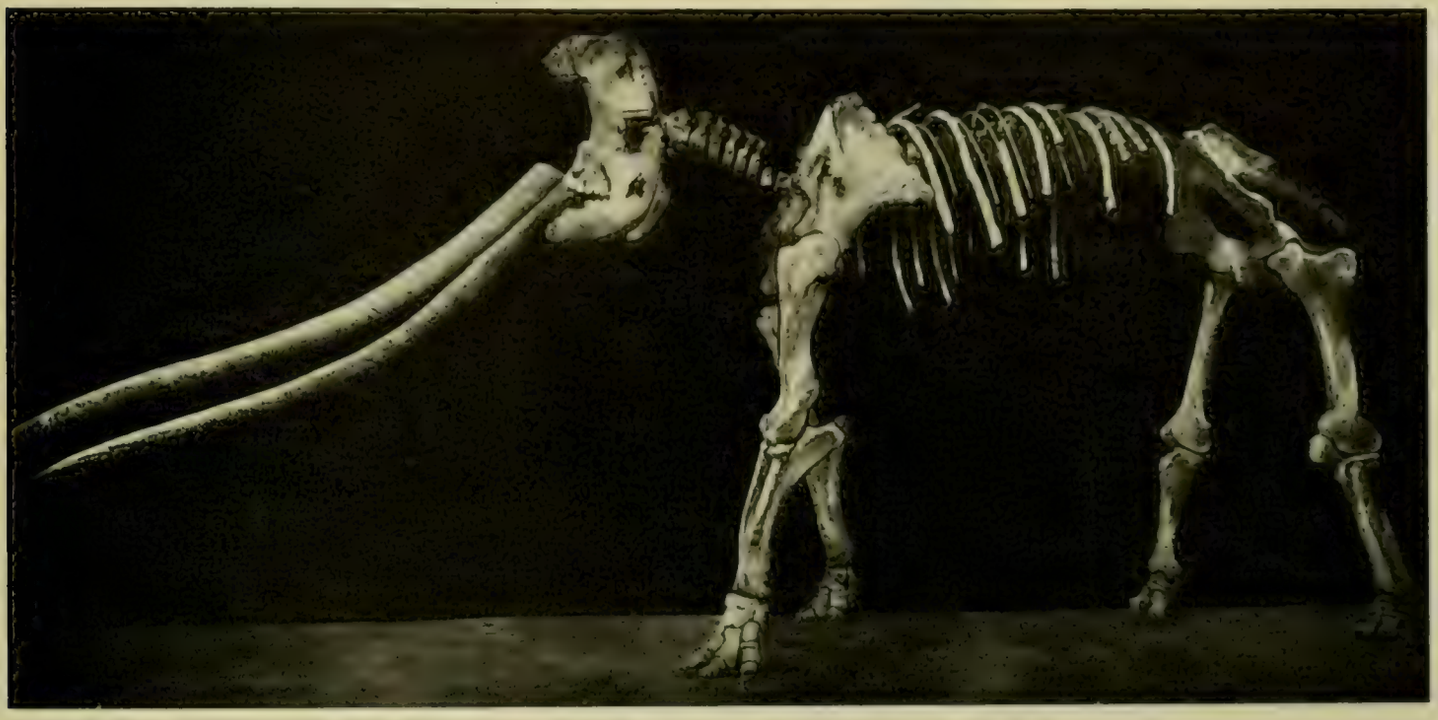


TURIN MUSEUM SKELETON OF ANANCUS ARVERNENSIS

Fig. 584. The Turin Museum skeleton of '*Mastodon*' *arvernensis*, as originally figured by Sismonda in 1851 (Sismonda, 1851, Tav. VI). Reproduced one-thirtieth natural size. Falconer says of this (1868, II, p. 26): "Of *M.* (*Tetraloph.*) *Arvernensis*, a nearly entire skeleton was disclosed by a railway excavation at Dusino, near Asti in Piedmont, and is now deposited in the Turin Museum. It is deficient only in the cranial portion of the head, right hind-leg, part of the scapula and pelvis, and some of the bones of the carpus and tarsus. The upper and lower jaws, with the tusks entire to their tips, are preserved; and Prof. Sismonda was only deterred by the brittle condition of the bones from attempting to reconstruct the whole."

in 1846 as *Mastodon brevirostre*. (4) In 1855 Aymard (Aymard in Dorlhac, 1855, p. 507) named a similar animal from near Puy, France, *Anancus macroplus*. (5) In 1840 Jourdan began to lecture on this animal as *Mastodon dissimilis*, expressing the possibility that it was equivalent to *M. arvernensis;* in 1858 he described and named the species *M. dissimilis* from the Saône basin. (6) In their revision of 1879, Lortet and Chantre (pp. 297–303) reviewed these three species of proboscideans under the name *Mastodon dissimilis*, namely: *Mastodon arvernensis*, *M. brevirostris*, *Anancus macroplus*. (7) As a consequence of these early successive descriptions the nomenclature and relationships of these animals were in great confusion and we warmly welcome the revision by Lortet and Chantre of 1879 and the subsequent thorough study and establishment of the real anatomical characters of the collective

species *Mastodon arvernensis* by Depéret in 1885 and 1890. (8) Meanwhile the generic name *Anancus* Aymard, 1855, signifying 'straight-tusked' mastodont, although cited by Lartet in 1859, p. 493, and subsequently by others (including the present author, 1918.468, table), did not gain general acceptance until 1923, when it was redefined by Hay in his paper "Characteristics of Sundry Fossil Vertebrates" (1923.2, p. 112). It was employed by Osborn in the same year (1923.603, pp. 47, 49, "Linnæan Classification and Phylogenetic Classification of the Proboscidea") when redefining his subfamily Brevirostrinæ, also in 1925 (1925.637, p. 16, and 1925.662, p. 27). In a recent paper by Gidley, entitled, "Fossil Proboscidea and Edentata of the San Pedro Vally, Arizona" (1926, p. 85), he described a new species from Texas as *Anancus bensonensis*, which, however, the present writer regards as referable rather to the genus *Cordillerion*. Also Osborn described in 1926 (1926.706, p. 13) the new species *Anancus falconeri*.



Bologna Museum Skeleton of Anancus arvernensis

Fig. 585. Skeleton of '*Mastodon*' *arvernensis* at the Royal University of Bologna, Italy, one-thirtieth natural size. Reproduced through the courtesy of Professor G. Capellini from a photograph of the specimen. Compare this photographic reproduction with Tav. II of Capellini's monograph of 1908, entitled, "Mastodonti del Museo Geologico di Bologna," together with his description and measurements of this superb specimen.

Falconer (1868, II, p. 26) makes reference to this specimen as follows: "A skeleton of the same species [*M. arvernensis*], nearly as perfect [as the skeleton in the Turin Museum, see Fig. 584], which I have examined, was discovered in the lower Val d'Arno in a marine stratum, along with the skeleton of a Whale. It is now laid out in the Museum at Florence, together with numerous other bones of the same species."

Specific Characters of Mastodon arvernensis (Depéret, 1885–1890).—In his first article Depéret (1885, p. 159) observes: "Les caractères essentiels du *Mastodon arvernensis* peuvent être résumés dans les points suivants: Espèce de grande taille, à formes robustes, munie à la mâchoire supérieure de défenses ou incisives courbées en spirale, et pouvant atteindre 3 mètres de longueur. Contrairement à l'opinion de Lartet et de P. Gervais [Footnote: 'Zoologie et paléontologie générales, 1869, p. 148.'], je crois que ces défenses portaient, comme chez le *M. angustidens*, sur leur face interne, une bande d'émail destinée à servir de surface de frottement." Depéret subsequently (1890) referred to the enamel band as a juvenile character only. Depéret in his revision of 1890 refers all specimens found in France and Italy to *M. arvernensis* and mentions many localities in southern France, on the slopes of the Pyrenees, and in northern Italy where this animal occurs. The characters established in these successive descriptions and enumerated by Depéret are: (1) Molars elongate, hence at first confused

with those of *M. angustidens;* (2) primitively bunomastodont, with trefoils on the outer side of the lower molars and on the inner side of the upper molars, as in primitive members of the Longirostrine phylum; (3) inner and outer cones *alternate* not opposite; this is the most distinctive and diagnostic character of the grinding teeth; (4) ridge formula, in the Middle Pliocene: M $2\frac{4}{4}$ M $3\frac{5\frac{1}{2}}{5\frac{1}{2}}$; (5) rapid abbreviation of the lower jaw, hence the term "*brevirostre*" of Gervais; (6) elongation and straightening of the superior tusks, with regular incurvation towards the extreme but without trace of spiral torsion (Depéret, 1890, p. 63); superior tusks with an internal band of enamel in the juvenile condition (Gervais, Sismonda, also Depéret, 1890, p. 63), without enamel in the adult condition; (7) no lower tusks.

Fig. 97.

Last upper molar, *Mastodon angustidens*, Fluvio-marine Crag, Norfolk. $\frac{1}{3}$ nat. size.

William Smith's (1816) Whitlingham Tooth

Fig. 586. The last upper molar, M^3, of '*Mastodon*' *arvernensis*, from the Norwich Crag, referred by Richard Owen ("British Fossil Mammals," 1846, p. 276, fig. 97) to *Mastodon angustidens*. One-third natural size. This figure displays the compression of the cones and the columnar character of the intermediate conules. The specimen is described by Lydekker (1886, p. 54) as follows: "[Brit. Mus.] M.1983. The third left upper true molar (imperfect anteriorly), in an early stage of wear; from the Norwich Crag of Norfolk. This specimen [the famous Whitlingham tooth, *fide* Falconer, 1867, p. 48] is figured in the frontispiece to William Smith's 'Strata identified by Organic Fossils' (1816), and in Owen's 'British Fossil Mammals and Birds,' p. 276, fig. 97 (as *M. angustidens*), and by Falconer and Cautley in the 'Fauna Antiqua Sivalensis,' pl. xxxvi. figs. 8, 8*a*. *William Smith's Collection.*"

Note (Osborn): This third superior molar of the right side, r.M^3, is referable to the progressive species *Anancus falconeri* Osborn.

Fig. 13.

Mastodon arvernensis.—The fourth left upper milk-molar; from the Norwich Crag of Postwick, Norfolk. $\frac{1}{2}$. The lower border of the figure is the inner border of the specimen.

Fluted Deciduous Superior Premolar

Fig. 587. Norwich Crag. Tooth of '*Mastodon*' *arvernensis* regarded by Lydekker (1886, p. 53) as a fourth left upper milk molar. Natural size. After Lydekker, *op. cit.*, p. 53, fig. 13. It is very important to note that the sides of the main cones are *deeply fluted* as in the cotype molars of '*M.*' *arvernensis* from Perrier, a character not observed in the specimens figured by Falconer and Owen. This corrugated character is attributed by Lydekker (cf. pp. 47 and 53), in his definition of the species *arvernensis*, to the milk molars chiefly: "the enamel of the milk-molars is vertically grooved but in the true molars it may be either grooved or smooth; and premolars have not been observed" (*op. cit.*, p. 47). Again in describing '*M.*' *arvernensis* Lydekker (*op. cit.*, p. 53) writes: "The columns of the ridges are very tall, and incline forwards in the lower teeth. In some adult molars the enamel is grooved, while in others it is quite smooth. A fourth upper milk-molar is figured in the accompanying woodcut (fig. 13); and full-sized figures of $m.^3$ are given by Fritsch in the Jahrb. k. preuss. geol. Land. 1884, pls. xxiii., xxiv."

Note (Osborn): This is a fourth left superior deciduous premolar, l.Dp^4, of *Anancus falconeri* Osborn.

1816–1846. Anancus found in the Upper Pliocene Norwich Crag and Red Crag of England

(1) A last upper molar (Fig. 586), known as 'the famous Whitlingham tooth,' was figured as early as 1816 in the frontispiece to William Smith's "Strata identified by Organized Fossils," according to a note by Falconer (1867, p. 48). The same tooth was referred to *Mastodon angustidens* in Richard Owen's 'A History of British Fossil Mammals and Birds," 1846, p. 276, fig. 97.

(2) Falconer was apparently the first to recognize the relationship of this 'famous Whitlingham tooth' to *Mastodon arvernensis* of Auvergne, although in the beginning he confused it with the *Mastodon longirostris* of Kaup, just as Richard Owen confused it with the *M. angustidens* of Cuvier. In the "Fauna Antiqua Sivalensis" Falconer figured three teeth of what he calls the "English Crag Mastodon," namely: 1847, Pl. xxxvi, figs. 7, 7a,

Norwich Crag (a vertically furrowed last superior milk molar), figs. 8, 8a, Norwich Crag (the famous Whitlingham tooth), and figs. 9, 9a, Red (?) Crag (a specimen dredged up between Southwold and Easton); he described them in 1867 (Falconer 1867, pp. 47, 48).

(3) In 1926 Osborn pointed out (1926.706, p. 13) that the high-crowned Norwich and Red Crag molar teeth belong to a much more progressive stage than the typical low-crowned '*M.*' *arvernensis* of Auvergne, and for this progressive, subhypsodont stage he proposed the name *Anancus falconeri*, in honor of Sir Hugh Falconer.

(4) We owe to Falconer the recognition of the affinity of this Norwich Crag animal to the *Mastodon* [=*Pentalophodon*] *sivalensis* Cautley, 1836, of India.

PRIMITIVE ANANCUS MOLARS OF EUROPE AND OF INDIA

Fig. 588. First and second inferior molars of the right side, r.M_{1-2}, of '*Mastodon*' [=*Anancus*] *arvernensis*, characterized by Schlesinger as an exceptionally typical specimen. Locality unknown; horizon probably Middle Pliocene. Original in the Natural History Museum of Vienna. After Schlesinger, 1917, Taf. xx, fig. 1, reduced to one-third natural size. Compare figure 589.

ANANCUS PERIMENSIS FROM PERIM ISLAND, INDIA

Fig. 589. Two lower molars, l.M_{2-3}, from the Middle Pliocene of Perim Island, India, referred by Falconer and Lydekker to '*Mastodon*' [=*Anancus*] *perimensis* (same as Fig. 606, 10). After Falconer and Cautley, 1846 [1847, Pl. xxxi, fig. 10].

Observe transverse alternation, dislocation, or *proversion* of the internal cones.

2. DISCOVERIES IN EASTERN EUROPE AND IN ASIA (EICHWALD, FALCONER, KHOMENKO, PILGRIM, BROWN, 1831–1922)

(1) VOLHYNIA.—As early as 1831 Eichwald described the more primitive *Mastodon intermedius* from Volhynia, southwestern Russia. This is clearly *Anancus intermedius*.

(2) SIWALIKS.—In 1836 Cautley described his *Mastodon sivalensis* from the Siwaliks of India, an animal now believed to be of Upper Pliocene age, namely, Upper Siwaliks.

This animal Falconer distinguished in 1857, p. 314, and 1865, p. 262, as *Pentalophodon sivalensis*, because it has five ridge-crested second molars; whereas *Mastodon* has three ridge-crested second molars. He wrote (1857, p. 314): "For reasons which will be explained in the sequel, it would seem that there has existed in nature another subgeneric group of *Mastodon*, of which only a single form is at present known, in which the crowns of the 'intermediate molars' are divided upon a quinary ridge-formula. This group in our arrangement would be characterized, in harmony with the others, as *Pentalophodon:* and it may with some confidence be predicated, that, when the dentition shall have been well determined, the second milk-molar will present four ridges, and the last true molar six ridges in the upper jaw."

(3) PERIM ISLAND.—In 1847 Falconer figured in the "Fauna Antiqua Sivalensis," Pl. xxxi, figs. 9, 9*a*, the much more primitive *Mastodon perimensis* from the Middle Pliocene of Perim Island, and in 1867, p. 44, described this species as presenting molar characters similar to those of *M. sivalensis* and *M. arvernensis:* in fact, we owe to

Falconer's keen vision immediate recognition of the fundamental (i. e., phyletic) similarity between the grinding teeth of *M. sivalensis* and *M. perimensis* of India and those of *M. arvernensis* of the Upper Pliocene Norwich Crag of England. The Perim Island fauna is of Middle Pliocene age.

(4) Dhok Pathan.—In 1913 Pilgrim described from the Middle Pliocene Dhok Pathan horizon of the Siwaliks the species *'Tetrabelodon' corrugatus* (which Lydekker had termed *'Mastodon' pandionis*); also from the vicinity of Bhimbar the species *Mastodon hasnoti* (termed by Lydekker *'Mastodon' sivalensis*), which he recognized as having dental characters of the grinding teeth similar to those of *M. arvernensis* and *M. sivalensis*. He distinguished *M. hasnoti* (p. 293) from the previously described Upper Pliocene *Mastodon sivalensis* of Falconer "[1] by being tetralophodont instead of pentalophodont, [2] by having the alternation of the columns very slightly marked." *Mastodon hasnoti* is of Middle Pliocene age, subsequent to Pikermi and Eppelsheim.

(5) Perim Island.—In 1913, p. 321, Pilgrim pointed out that the abundant Proboscidea of Perim Island, including the type of *Mastodon* [=*Anancus*] *perimensis*, were accompanied by a rich mammalian fauna of more recent geologic date than the Upper Chinjis (which entirely lack the *Mastodon* [=*Stegolophodon*] *cautleyi* and contain species, e. g., *Hipparion punjabiense*, close to those of the Middle Pliocene Dhok Pathan). Thus he concludes [Chap. X, figs. 413, 414] that the types of *Mastodon* [=*Anancus*] *perimensis* and of *Mastodon* [=*Stegolophodon*] *cautleyi* belong to the Middle Pliocene.

(6) In 1918 Osborn (1918.468, table opp. p. 134) and again in 1923 (1923.603, pp. 47, 49) applied the generic name *Anancus* to the species *Mastodon arvernensis*, and in the present Memoir he embraces within this genus the following species: *Mastodon intermedius* Eichwald, 1831, *M. brevirostre* Gervais and de Serres, 1846, *M. perimensis* Falconer and Cautley, 1847, *M. dissimilis* Jourdan, 1858, and other species, including *Anancus properimensis* sp. nov.

(7) In 1925 Osborn adopted (1925.637, p. 16, and 1925.662, p. 27) Falconer's generic name *Pentalophodon* (genotype, *Mastodon sivalensis* Cautley) for species of mastodonts in which the 'intermediate molars' are five crested, and in the present Memoir he refers to *M. sivalensis* as *Pentalophodon sivalensis*. He describes herein (p. 653) the new species *Pentalophodon falconeri*.

(8) In the year 1922 Barnum Brown discovered in the Middle Pliocene Dhok Pathan horizon of the Middle Siwaliks, India, and in the more ancient underlying horizon of the Lower Siwaliks, a finely preserved skull and the remains of grinding teeth belonging to ten individuals which represent a new genus of the Brevirostrinæ, including five species, described by Osborn in the present Memoir as *Synconolophus dhokpathanensis* type, *S. propathanensis* type, *S. corrugatus* type, and *S. hasnoti* type of Middle Pliocene age (see p. 660 and Fig. 627) also *S. ptychodus* type of the Lower Chinji horizon.

3. DISCOVERY AND DESCRIPTION OF HUMBOLDTINÆ (STEGOMASTODON) AND OF NOTORROSTRINÆ (CORDILLERION) IN NORTH AMERICA (1834–1930)

The first members of the Humboldtinæ discovered in America were the *Mastodon chapmani* Hays, 1834, and the *Mastodon mirificus* Leidy, 1858. Neither author recognized the fundamental resemblance to the *Mastodon arvernensis* of the Auvergne in the alternation of the internal and external cones of the grinding teeth. Leidy was impressed with the highly complicated ptychoid or plicate character of the enamel, to which the adjective *mirificus* doubtless applies. To this and to other generic distinctions of certain of the American mastodonts Pohlig applied the new generic name *Stegomastodon* in 1912, and Hay the new generic name *Rhabdobunus* in 1914.

The European name *Anancus*, signifying straight tusks, does not apply to these American forms, in which the tusks are short, massive, and abruptly curved (Fig. 634); the '*Anancus*' *brazosius* Hay, 1923, is referred in the present Memoir to *Trilophodon* (?*Tetralophodon*) *brazosius*. The '*Anancus*' *orarius* and '*A.*' *defloccatus* Hay, 1926, of Texas, are both referable to the genus *Cordillerion;* to this Notorostrine phylum should also be added the '*Anancus*' *bensonensis* Gidley, 1926, namely, *Cordillerion bensonensis*. The true generic stage of *Anancus* certainly does not occur in North America.

1834. 'Mastodon' chapmani, probably from the "ancient Territory of Nebraska." It is certainly remarkable that in 1834, only six years after Croizet and Jobert described the first species *Mastodon arvernensis* of the Auvergne, Dr. Isaac Hays, a palæontologist of Philadelphia, came into the possession of a fragmentary molar from an unknown locality, probably from the "ancient territory of Nebraska," to which the name *Mastodon chapmani* was given; this molar tooth unquestionably belongs to the phylum *Stegomastodon*.

= *Stegomastodon chapmani*.

1858. 'Mastodon' mirificus of Nebraska. It was not until 1858, thirty years after Croizet and Jobert's description, that Leidy described from the "Loup Fork of Platte River" a characteristic lower jaw to which he gave the name *Mastodon mirificus*, the adjective *mirificus* doubtless referring to the highly complicated, ptychoid character of the grinding teeth in contrast to the simpler grinding teeth of *Mastodon* and *Trilophodon*.

= *Stegomastodon mirificus*.

1892. 'Mastodon' successor of the Blanco, Texas.—*Mastodon successor* Cope (name withdrawn by Cope in 1893 and erroneously regarded as a synonym of *Dibelodon tropicus*) now proves to

= *Stegomastodon successor*.

1923. 'Anancus' brazosius of Texas.—In 1923 Hay added the name *Anancus brazosius* from a type found on the Brazos River near San Felipe, Texas. . . . . = *Trilophodon* (?*Tetralophodon*) *brazosius*.

1924. Stegomastodon texanus of Texas.—Remains of these animals are extremely rare in the museums of the United States, in fact, the four types above mentioned were the only ones described until 1924 when James W. Gidley published his discovery of a large deposit of these Humboldtines in the Blanco formation of Texas, which Gidley and Osborn at first referred to the species *Mastodon mirificus*, but which Osborn subsequently (1924.634) named *Stegomastodon texanus*. . . . . = *Stegomastodon texanus*.

1924. Stegomastodon aftoniæ.—In the year 1924 Osborn (1924.634) also described *Stegomastodon aftoniæ* of the Lower to Middle Pleistocene of Iowa, a contemporary of the giant southern mammoth *Archidiskodon imperator* of Leidy, apparently the last survivor of the subfamily Humboldtinæ in North America.

= *Stegomastodon aftoniæ*.

1924. Stegomastodon nebrascensis. In 1924 Osborn described *Stegomastodon nebrascensis* from the Snake Creek of Nebraska. This proves (1933) to be a true Serridentine. . . . . = *Serridentinus nebrascensis*.

1924, 1926. Stegomastodon arizonæ of Arizona.—In 1921 James W. Gidley (Gidley, 1922) explored the San Pedro Valley, Cochise County, Arizona, and discovered another very rich deposit of extreme desert origin, from which he secured complete skulls and a superb skeleton (Fig. 634) of the species *Stegomastodon arizonæ* (in Osborn, 1924), Gidley, 1926. . . . . = *Stegomastodon arizonæ*.

1926. 'Anancus' orarius and 'A.' defloccatus of Texas.—In 1926 Hay described as '*Anancus*' *orarius*, from near Sinton, Texas, west bank of the Aransas River, San Patricio County, grinding teeth which are referable to another genus and subfamily, namely, *Cordillerion* of the subfamily Notorostrinæ. In the year 1926 he also named from the same locality *Anancus defloccatus*, which the present author refers to *Cordillerion*.

= *Cordillerion orarius* and *C. defloccatus*.

1926. 'Anancus' bensonensis of Arizona.—In 1926 Gidley described from the San Pedro valley, near Benson, Arizona, the species *Anancus bensonensis*, which the present author also refers to the genus *Cordillerion*. ..... = *Cordillerion bensonensis.*

1930. Gomphotherium priestleyi of Oklahoma.—In 1930 Hay and Cook described from Frederick, Tillman County, Oklahoma, the species *Gomphotherium priestleyi*, which the present author regards as referable to *Stegomastodon* ..... = *Stegomastodon priestleyi.*

Summary.—The types of four of the above species show that they were improperly referred to *Anancus* and are properly referable to the genera *Cordillerion* and *Trilophodon*. The types of seven of the above species exhibit in various progressive stages the distinctive characters of the grinding teeth observed by Leidy in his description of *'Mastodon' mirificus*, but the specific differences between these seven American species of *Stegomastodon* cannot be clearly defined at present.

The list of species of American Humboldtines, therefore, should stand at present as follows[1]:

Properly Referred to Stegomastodon

1834 *Mastodon chapmani* Hays = *Stegomastodon chapmani*
1858 *Mastodon mirificus* Leidy = *Stegomastodon mirificus*
1892 *Mastodon successor* Cope = *Stegomastodon successor*
1924 *Stegomastodon texanus* Osborn = *Stegomastodon texanus*
1924 *Stegomastodon aftoniæ* Osborn = *Stegomastodon aftoniæ*
1924–1926 *Stegomastodon arizonæ* Gidley = *Stegomastodon arizonæ*
1930 *Gomphotherium priestleyi* Hay and Cook = *Stegomastodon priestleyi*

Improperly Referred to Anancus

1923 *Anancus brazosius* Hay = *Trilophodon (Tetralophodon?) brazosius*
1926 *Anancus orarius* Hay = *Cordillerion orarius*
1926 *Anancus defloccatus* Hay = *Cordillerion defloccatus*
1926 *Anancus bensonensis* Gidley = *Cordillerion bensonensis*

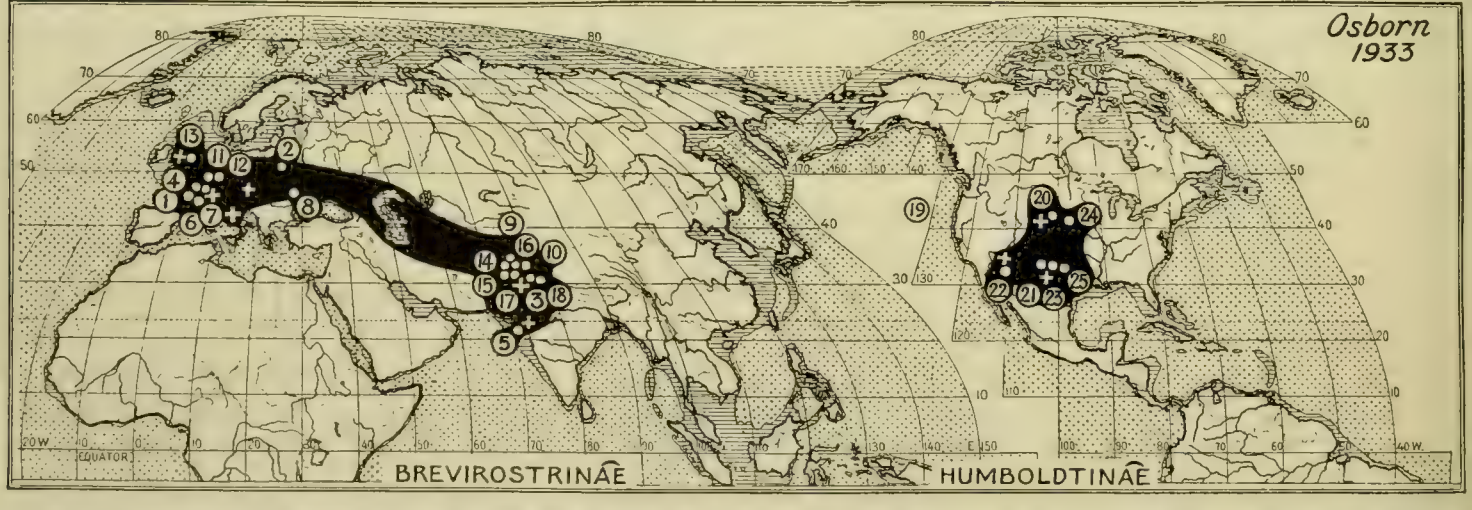


Fig. 590. Geographic distribution of the eighteen[1] species of Brevirostrinæ of Eurasia and of the seven[2] Humboldtinæ of North America, according to list on opposite page. The white dots within the black areas represent the approximate localities where the types were discovered. The crosses represent referred specimens mentioned in the present Memoir.

Compare Chap. XII, p. 536, fig. 501, for palæogeographic range of the Humboldtinæ in the southern United States and South America, and other members of the Proboscidean order.

[1] *Anancus sinensis* Hopwood, 1935, was described too late for insertion on this map (see Appendix to the present Volume I for review and figure). This makes nineteen species in all.

[2] See Appendix of the present Volume I for description of *Stegomastodon primitivus* sp. nov., making eight species of Humboldtinæ in North America.

4. SYNOPSIS OF THE NINETEEN SPECIES OF BREVIROSTRINÆ THUS FAR DISCOVERED IN FRANCE, ENGLAND, GERMANY, RUSSIA, INDIA, AND CHINA; ALSO OF THE EIGHT HUMBOLDTINÆ DISCOVERED IN NEBRASKA, TEXAS, ARIZONA, IOWA, AND OKLAHOMA

See Figure 590

Original Name			Specific Reference in Present Memoir
		BREVIROSTRINÆ OF EURASIA	
1. Auvergne, France	1828	*Mastodon arvernensis* Croizet and Jobert	= *Anancus arvernensis*
2. Volhynia, Russia	1831	*Mastodon intermedius* Eichwald	= *Anancus intermedius*
3. Upper Siwaliks, near Nahun, India	1836	*Mastodon Sivalensis* Cautley	= *Pentalophodon sivalensis*
4. Montpellier, Hérault, France	1846	*Mastodon brevirostre* Gervais and de Serres	= *Anancus arvernensis brevirostris*
5. Perim Island, India	1847	*Mastodon perimensis* Falconer and Cautley	= *Anancus perimensis*
6. Mt. Coupet, Puy-en-Velay, France	1855		
	1859	*Anancus macroplus* Aymard	= *Anancus arvernensis macroplus*
7. Saône basin, France	1858	*Mastodon dissimilis* Jourdan	= *Anancus arvernensis dissimilis*
8. Near Gavanosy, Ismaïl, southern Bessarabia, Russia	1912	*Mastodon arvernensis* Croiz. et Job. var. *progressor* Khomenko	= *Anancus arvernensis progressor*
Italy	1912	*Mastodon arvernensis* Croiz. et Job. var. *conservativus* Khomenko	= *Nomen nudum*
9. Hasnot, Dhok Pathan, India	1913	*Tetrabelodon corrugatus* Pilgrim	= *Synconolophus corrugatus*
10. Bhimbar, India	1913	*Mastodon hasnoti* Pilgrim	= *Synconolophus hasnoti*
11. Herbolzheim, Germany	1922	*Mastodon minutoarvernensis* Klähn	= *Anancus minutoarvernensis*
12. Herbolzheim, Germany	1922	*Mastodon gigantarvernensis* Klähn	= *Anancus gigantarvernensis*
13. Red Crag of Suffolk, England	1926	*Anancus falconeri* Osborn	= *Anancus falconeri*
14. Near Dhok Pathan, India	1929	*Synconolophus dhokpathanensis* Osborn	= *Synconolophus dhokpathanensis*
15. Near Chinji Bungalow, India	1929	*Synconolophus ptychodus* Osborn	= *Synconolophus ptychodus*
16. Near Dhok Pathan, India	1929	*Synconolophus propathanensis* Osborn	= *Synconolophus propathanensis*
Pati-Ajam, near Pati, Middle Java	1933	*Cryptomastodon martini* von Koenigswald	= Sirenian(?) (cf. *Desmostylus*)
17. Shansi, China	1935	*Pentalophodon sinensis* Hopwood	= *Anancus sinensis*
18 Mio-Pliocene, near Chinji Bungalow, Upper Chinji, India		*Anancus properimensis* sp. nov.	= *Anancus properimensis* sp. nov.
19. Upper Pliocene, Upper Siwaliks, India		*Pentalophodon falconeri* sp. nov.	= *Pentalophodon falconeri* sp. nov.
		HUMBOLDTINÆ OF NORTH AMERICA	
1. Upper Pliocene-Pleistocene, Nebraska(?)	1834–1843	*Mastodon chapmani* Hays	= *Stegomastodon chapmani*
2. Pliocene-Lower Pleistocene(?),[1] Nebraska	1858	*Mastodon mirificus* Leidy	= *Stegomastodon mirificus*
3. Upper Pliocene, Blanco formation, Texas	1892	*Mastodon successor* Cope	= *Stegomastodon successor*
[Brazos River, Texas	1923	*Anancus brazosius* Hay	= *Trilophodon* (?*Tetralophodon*) *brazosius*—see Chaps. VIII, IX]
4. Upper Pliocene, Curtis Flats, Cochise County, Arizona	1924–1926	*Stegomastodon arizonæ* Gidley (in Osborn, 1924), Gidley, 1926	= *Stegomastodon arizonæ*
5. Upper Pliocene, Blanco formation, Texas	1924	*Stegomastodon texanus* Osborn	= *Stegomastodon texanus*
6. Lower Pleistocene,[2] Akron, Iowa	1924	*Stegomastodon aftoniæ* Osborn	= *Stegomastodon aftoniæ*
[Lower Pliocene, Snake Creek, Nebraska	1924	*Stegomastodon nebrascensis* Osborn	= *Serridentinus nebrascensis*—see Chap. X]
[Near Sinton, Texas	1926	*Anancus orarius* Hay	= *Cordillerion orarius*—see Chap. XII]
[Near Sinton, Texas	1926	*Anancus defloccatus* Hay	= *Cordillerion defloccatus*—see Chap. XII]
[Near Benson, Arizona	1926	*Anancus bensonensis* Gidley	= *Cordillerion bensonensis*—see Chap. XII]
7. Near Frederick, Tillman Co., Oklahoma	1930	*Gomphotherium priestleyi* Hay and Cook	= *Stegomastodon priestleyi*
8. Lower Pleistocene, near Ainsworth, Nebraska		*Stegomastodon primitivus* sp. nov.	= *Stegomastodon primitivus* sp. nov.

[1]Lower to Middle Pleistocene (see Lugn and Schultz, 1934.1, p. 372).

[2]Lower to Middle Pleistocene (see footnote 1 on page 671 below).

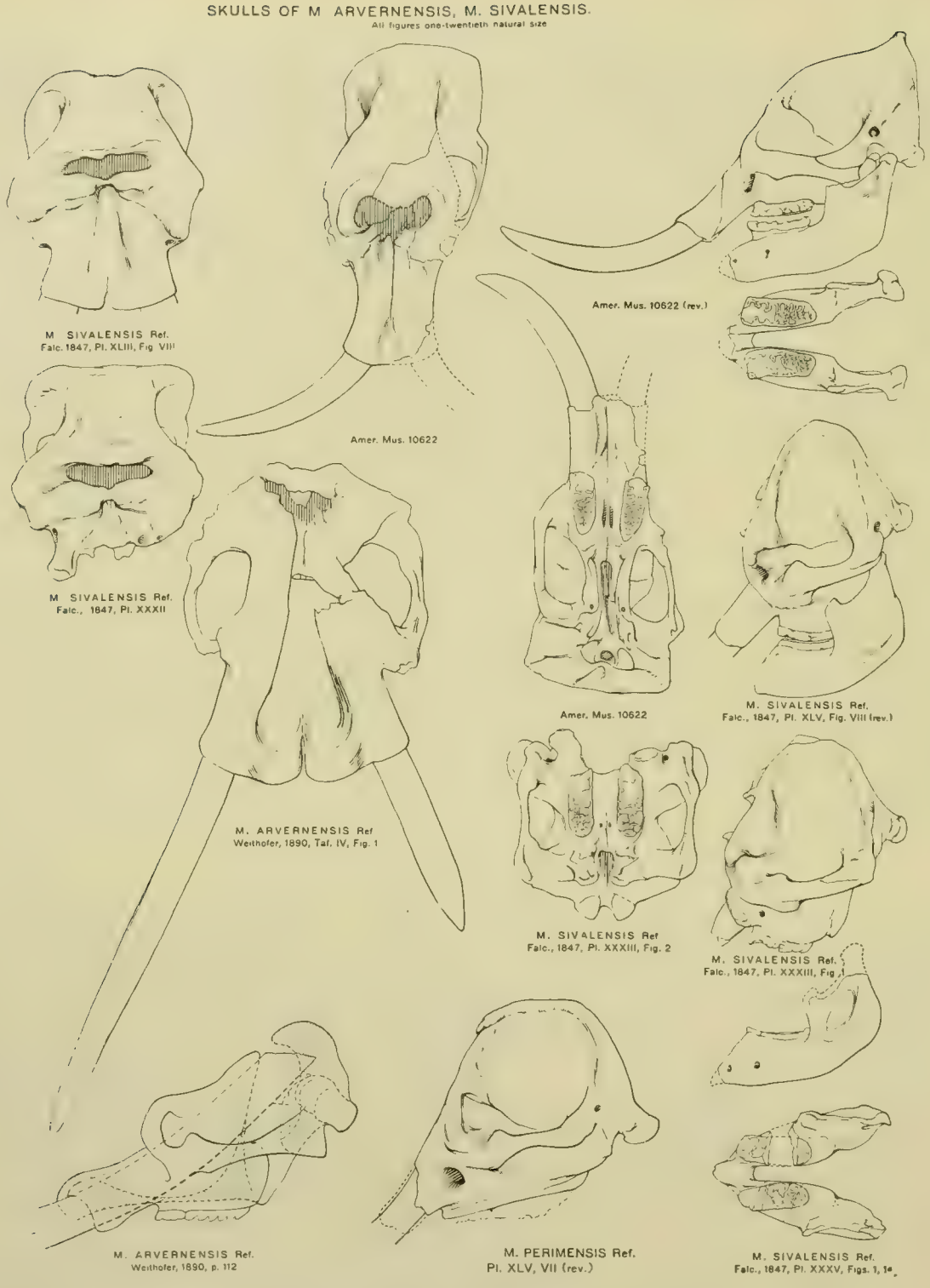


Fig. 591. Crania of Brevirostrinæ from Italy and India, and Stegomastodon (Humboldtinæ) of the United States (Texas). All figures one-twentieth natural size

Pentalophodon — Referred skull, front view, of *Mastodon* [=*Pentalophodon*] *sivalensis* [=*falconeri*], after Falconer and Cautley, 1846 [1847, Pl. xliii, fig. viii]. Side view of same skull, Pl. xlv, fig. viii (rev.).

Second referred skull, front view, of *Mastodon* [=*Pentalophodon*] *sivalensis* [=*falconeri*], after Falconer and Cautley, 1846 [1847, Pl. xxxii]. Side view of same, Pl. xxxiii, fig. 1. Palatal view of same, Pl. xxxiii, fig. 2.

Referred jaws of *Mastodon* [=*Pentalophodon*] *sivalensis*, after Falconer and Cautley, 1846 [1847, Pl. xxxv, figs. 1, 1*a*].

Anancus — Referred skull, front view, of *Mastodon* [=*Anancus*] *arvernensis*, after Weithofer, 1890, Tav. iv, fig. 1. Side view of juvenile skull, after Weithofer, 1890, p. 112.

Referred skull, side view, of *Mastodon* [=*Anancus*] *perimensis*, after Falconer and Cautley, 1846 [1847, Pl. xlv, fig. vii (rev.)].

Stegomastodon — *Stegomastodon texanus* type skull and jaws, three views of skull in outline and superior view of lower jaws (Amer. Mus. 10622), reduced from figures 639, 642 of the present Memoir. To the number Amer. Mus. 10622 the reader should add the name *Stegomastodon texanus*.

II. CHARACTERS OF THE SUBFAMILY BREVIROSTRINÆ AND INCLUDED GENERA

SUPERFAMILY: MASTODONTOIDEA Osborn, 1921

FAMILY: BUNOMASTODONTIDÆ Osborn, 1921

SUBFAMILY: BREVIROSTRINAE Osborn, 1918

Original reference: Bull. Geol. Soc. Amer., Vol. XXIX, p. 136 (Osborn, 1918.468).

SUBFAMILY CHARACTERS.—(1) Skull brachycephalic, brevirostral. (2) Jaws rapidly abbreviating, in correlation with loss of lower tusks; completely brevirostral in Upper Pliocene time, as in *Mastodon* and *Elephas*. (3) Lower tusks disappearing early; milk tusks with enamel (*Synconolophus*). (4) Upper tusks straight, upturned, out-turned, elongating, attaining great length (*Anancus arvernensis*). (5) Grinding teeth, originally short crowned, brachyodont, finally becoming subhypsodont with folded enamel, ptychodont; grinding action as in the Suoidea, taking the place of the chopping action of the *Mastodon* grinders. (6) Internal and external cones progressively *alternating* and *proverted*. (7) *Central conules* in *Anancus*, *Pentalophodon*, and *Synconolophus*, posterior lophs alternating and warped (*Synconolophus*). (8) Posterior grinders, M^3-M_3, multiplying crests to $6\frac{1}{2}$–7; anterior grinders disappearing relatively early. (9) 'Intermediate grinders' $3\frac{1}{2}$ crested (*Synconolophus*), 4 crested (*Anancus*), 5 crested (*Pentalophodon*).

HISTORY.—The interesting history, from the time of Cuvier to that of the present Memoir, of the gradual separation of the Brevirostrines from other bunomastodonts is fully told in Chapter V and need not be repeated here. In 1918 Osborn (1918.468, p. 136) proposed the subfamily name Brevirostrinæ, in allusion to the *Mastodon brevirostre* of Gervais and de Serres which is generally regarded as a synonym of the *Mastodon arvernensis* of Croizet and Jobert. In 1921 Osborn (1921.515, pp. 10 and 11) fully defined the Brevirostrinæ.

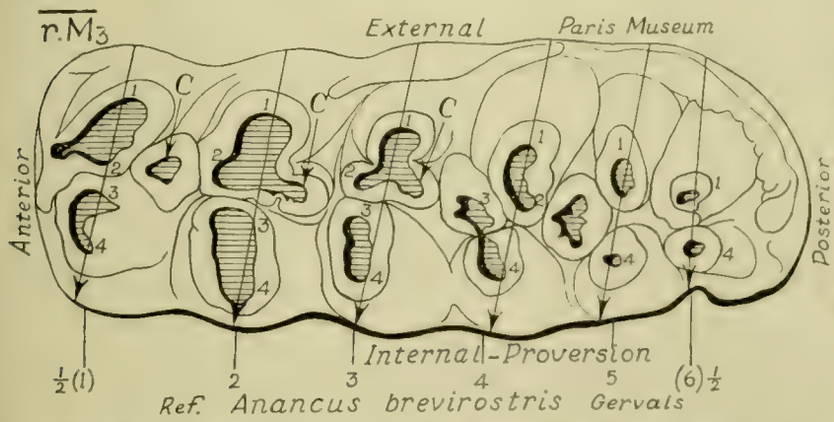


Fig. 592. Proversion of $5\frac{1}{2}$ (6) inferior ridge-crests in right third inferior molar, r.M_3, of *Anancus brevirostris*; 22 aristogenes including (C) central conules. Observe strong oblique angle of ridge-crests 3 to 5. One-half natural size.

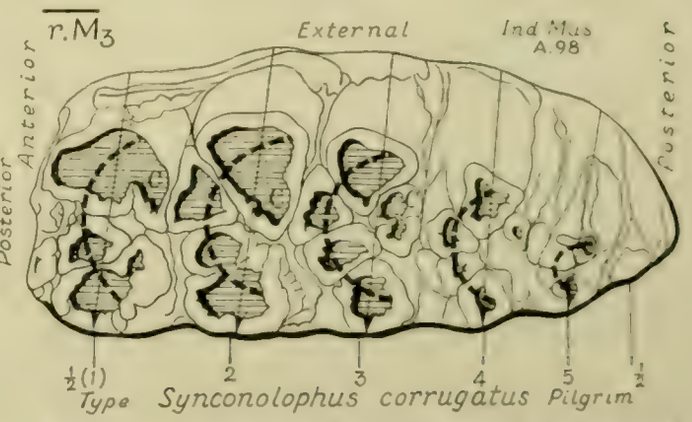


Fig. 593. Strong proversion of $5\frac{1}{2}$ (6) ridge-crests in the type third right inferior molar, r.M_3, of *Synconolophus corrugatus*, including 22 ± aristogenes, which obviously evolved a much simpler *Anancus brevirostris* form of molar. One-half natural size.

Anancus brevirostris, *A. perimensis*, *Synconolophus corrugatus*, and *A. hasnoti* (cf. Chap. XII, Fig. 581, p. 613).

COMPARATIVE CHARACTERS.—These short-jawed bunomastodonts are readily distinguished from all others by four principal characters: *First*, the skull and jaws short, as in the elephants; *second*, the grinding teeth finally reduced to one above and one below, as also in the elephants and in the Stegodonts; *third*, perhaps most distinctive and unique, the *alternation* of the main internal and external cones which are placed diagonally instead of transversely to the long axis of the crowns, a character first observed by Cautley in describing his species *Mastodon sivalensis* also by Falconer (1846, p. 50) in comparing the *Mastodon sivalensis* of the Siwaliks with *M. latidens*, and later (1868, II, pp. 29–31) with the *Mastodon arvernensis* of the British coast Upper Pliocene; the *fourth*

Brevirostrinæ

FRANCE, ENGLAND, GERMANY, RUSSIA, INDIA, CHINA

Anancus Aymard, 1855

Genotypic species: *Anancus macroplus* [=*Anancus arvernensis*] Aymard.

Incisive tusks straight, elongate.

Intermediate molars with four ridge-crests.

Ridge formula: M $2\frac{4}{4}$-$4\frac{1}{4}$ M $3\frac{5\frac{1}{2}}{5\frac{1}{2}}$-$\frac{6\frac{1}{2}}{6\frac{1}{2}}$. True molars brachyodont to subhypsodont. True molar cones simple, smooth, compressed fore and aft. *Single* external median conules in inferior molars, internal median conules in superior molars, as in *Trilophodon*. Deciduous molars (premolars) grooved, ptychoid, or plicated, externally.

Crowns brachyodont, cones erect (*A. macroplus* and related species); crowns subhypsodont, strongly inclined and alternating (*A. falconeri*). Central conules; no trefoils.

England: *Anancus falconeri*
France: *Anancus arvernensis*
Russia: *Anancus intermedius*
Asia: *Anancus perimensis*
Anancus properimensis

Pentalophodon Falconer, 1857

Genotypic species: *Mastodon sivalensis* Cautley.

Incisive tusks unknown.

Intermediate molars with five ridge-crests.

Ridge formula: M $2\frac{5}{5}$ M $3\frac{?}{6\frac{1}{2}}$-$\frac{7\frac{1}{2}}{7\frac{1}{2}?}$ Molars subhypsodont, cones elevated, strongly alternating.

Crowns subhypsodont, cones inclined forwards in the lower molars, and in the upper molars strongly alternating (*P. sivalensis*). No trefoils in Cautley's type (Fig. 616). Central conules; cones and conelets reduced in number.

Asia: *Pentalophodon sivalensis*
Pentalophodon falconeri

Synconolophus Osborn

Genotypic species: *Synconolophus dhokpathanensis* Osborn.

Incisive tusks long, massive, upcurved.

Intermediate molars with three and a half ridge-crests.

Known ridge formula: M $2^{3\frac{1}{2}+}$ M $3^{4\frac{1}{2}-5\frac{1}{2}}_{?\ 5\frac{1}{2}}$.

Molar crowns brachyodont to subhypsodont. In third superior molar, M^3, inner pair of cones enlarged in proto- to metalophs; in tritoloph inner cones compressed and strongly oblique in position; in trito- and tetartolophs conelets strongly compressed and crowded, hence the generic name *Synconolophus*. Central conlues; no trefoils.

Asia: *Synconolophus dhokpathanensis*
Synconolophus corrugatus
Synconolophus hasnoti
Synconolophus ptychodus
Synconolophus propathanensis

Humboldtinæ

AMERICA

Stegomastodon Pohlig, 1912

Genotypic species: *Mastodon mirificus* Leidy.

Incisive tusks short, massive, upcurved.

Intermediate molars with three and a half ridge-crests.

Ridge formula: M $1\ \frac{3\frac{1}{2}}{3\frac{1}{2}}$ M $2\ \frac{3\frac{1}{2}}{3\frac{1}{2}}$ M $3\ \frac{5\frac{1}{2}}{5\frac{1}{2}}$-$\frac{6\frac{1}{2}}{6\frac{1}{2}}$-$\frac{7\frac{1}{2}}{7\frac{1}{2}}$. Molar crowns brachyodont to subhypsodont, cones slightly alternating, deeply plicated, ptychoid, folded, giving a labyrinthine pattern to the worn grinding surfaces. *Double* to *quadruple* to *multiple* trefoils on superior (Fig. 650) and inferior (Fig. 643) molars.

Crowns brachyodont, cones erect (*S. mirificus*), crowns subhypsodont (*S. arizonæ*). No central conules.

America: *Stegomastodon chapmani*
Stegomastodon mirificus
Stegomastodon successor
Stegomastodon texanus
Stegomastodon arizonæ
Stegomastodon aftoniæ
Stegomastodon priestleyi
Stegomastodon primitivus

distinctive character is the plication or folding (*Synconolophus*) of the enamel borders of the molar ridges, giving the hippopotamus- and piglike character termed "chærodont" by Schlesinger, the grinding action of the teeth being obviously as in pigs, peccaries, and the hippopotami. The grinders, originally brachyodont, become subhypsodont; thus the single superior and inferior molar teeth become highly effective masticating organs, labyrinthodont in pattern and serving effectually in the comminution of food.

Geographic Range.—Armed with very powerful upper tusks, the enamel bands of which early disappear, propelled by massive limbs supported on a powerful frame, these animals appear to have been adapted to browsing on the succulent vegetation of the warm-temperate zones, chiefly of the 40th and 30th parallels, from France and the southeast coast of England, through northern Italy, then through India, but never reaching North America, so far as we know at present. Analogous but unrelated are the species of *Stegomastodon*.

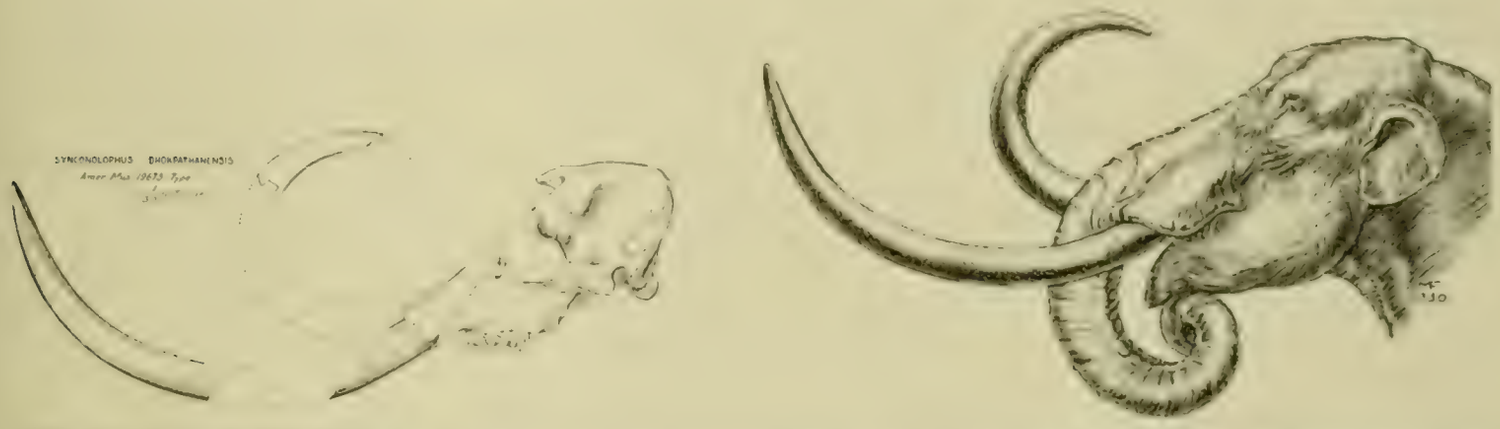


Fig. 594. Restoration (right) of the head of *Synconolophus dhokpathanensis* drawn under the direction of the author by Margret Flinsch, May 1, 1930, directly from the type cranium and tusks (left). Observe the extremely elevated position of the orbit, the flat, elongated rostrum, the low, rounded frontal contour. Ears conjectural. Right tusk abnormally upturned. Reduction to one-thirtieth natural size.

SYSTEMATIC AND PHYLOGENETIC REVISION

It is difficult and somewhat premature to attempt to distinguish the specific and generic stages in this unique Brevirostrine phylum. The Upper Pliocene species in France alone require very close comparison *inter se*.

A recent discovery is *Synconolophus* of India, with its long, upcurved tusks, representing a new generic phylum with extreme alternation and warping of the molar cones and crests.

A summary of the generic terms successively applied to these animals is therefore as follows:

1817 *'Mastodon'* by Cuvier and all subsequent authors until Osborn revived *Anancus* in the preparation of this Memoir.

1852 *'Tetralophodon'* by Warren, and as a section, i.e., subgenus of *'Mastodon'* (*Tetralophodon*), by Falconer in 1847–1868.

1855 *Anancus* by Aymard, based on the genotypic species *Anancus macroplus*, a synonym of *Anancus arvernensis*.

1857–1865 *Pentalophodon* by Falconer, based on the genotypic species *Mastodon sivalensis* of the Upper Pliocene.

1929 *Synconolophus* by Osborn, based on the genotypic species *Synconolophus dhokpathanensis* of the Middle Pliocene of India.

1. DEFINITION OF THE THREE GENERA, ANANCUS, PENTALOPHODON, AND SYNCONOLOPHUS

It now appears that we have to do with three phyla:

(1) The first purely Eurasiatic, in which belong *Anancus arvernensis* and *A. falconeri*, derived perhaps from *A. perimensis* or *A. properimensis*.

(2) It has proved that the Indian form *Pentalophodon sivalensis* also has a line of southern Asiatic ancestry of its own, branching from *Anancus perimensis* and distinct from the west European *Anancus arvernensis*. One reason for this supposition is that the Middle Pliocene *A. perimensis* has an even higher ridge formula, M 2 $\frac{4\frac{1}{2}}{4\frac{1}{2}}$ M 3 $\frac{5\frac{1}{2}}{6\frac{1}{2}}$, than that of the Upper Pliocene *A. arvernensis*, namely, M 3 $\frac{5\frac{1}{2}}{5\frac{1}{2}}$.

(3) A third phylum, *Synconolophus* Osborn, probably originated in southern Asia; first known in the species *Synconolophus ptychodus* of the Lower Chinji horizon, ascending into the *S. corrugatus* and *S. hasnoti* of the Dhok Pathan horizon, and finally evolving into the giant *S. dhokpathanensis* also of the Dhok Pathan horizon (Middle Pliocene).

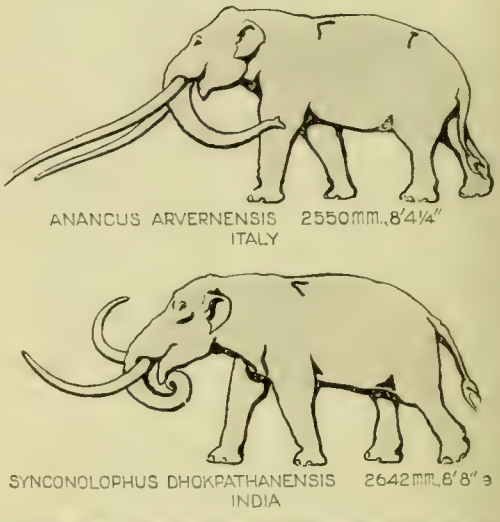


Fig. 595. Restorations of *Anancus* and *Synconolophus*, to a one-hundredth scale, by Margret Flinsch, under the direction of Henry Fairfield Osborn.

2. HISTORY AND DEFINITION OF THE GENUS ANANCUS

Genus: **ANANCUS** Aymard, 1855, 1859

Genotypic species: *Anancus macroplus* Aymard, 1855 [=*Mastodon arvernensis* Croizet and Jobert, 1828].
Syn.: Subgenus *Mastodon* (*Dibunodon*) *arvernense* Schlesinger, 1917, p. 124.

Aymard's generic characterization implied in the name *Anancus*, in allusion to the straight tusks or upper incisors, was a highly distinctive one and served excellently to define the genus, although this character does not distinguish all the species. Consequently the 'straight-tusked Mastodon' of Upper Pliocene time in France may be known by the prior generic name *Anancus*. Aymard was dilatory in publication and description as follows:

Aymard described (1847, p. 414) a metacarpal and two last molars but did not assign a name to them. The name *Anancus macroplus* appears in MS., however, on the labels of certain specimens in the Musée Crozatier at Puy, although the name was *not published* until 1855, publication occurring on page 507 of a communication by J. Dorlhac, who notes (p. 506, footnote): "Cette liste de fossiles est empruntée à une communication que M. Aymard a faite à la Société académique dans sa séance de janvier 1855." . . . [p. 507] "Mastodontes. Genre *Anancus*. Aym.: *Anancus macroplus*. Aym. *Mastodon*. Espèce indéterminée."

First mention by Aymard	1847, p. 414 (not named)
Anancus macroplus Aymard	1855, p. 507, in Dorlhac (without definition)
Anancus macroplus Aymard	1855 (verbal communication, published in 1859, p. 35)
Anancus macroplus Aymard cited in Lartet	1859, p. 493 (syn. of *Mastodon* [=*Anancus*] *arvernensis* Croizet and Jobert)

History of the Name.—In his "Index Generum Mammalium" of 1904, p. 99, Palmer cites this genus as follows:

Anancus Aymard, 1855. Ungulata, Proboscidea, Elephantidæ. Ann. Soc. Agr., Sci., Arts, et Comm. du Puy, XIX, for 1854, 507, 1855; XX, for 1855, 35, 1859; Congrès Sci. France, for 1855, I, 271, 1856; Lydekker, Cat. Foss. Mamm. Brit. Mus., IV, 52, 1886 (under *Mastodon arvernensis*). Type: *Anancus macroplus* Aymard, from Mt. Coupet, near Puy, France. Extinct. *Anancus*, ἄν, without; ἄγκος, bend, hollow—probably in allusion to the tusks or upper incisors, which are straight in comparison with those of some species of *Elephas*.

(Palmer, T. S., letter, October 23, 1926): In a communication from Dr. Palmer of October 23, 1926, he writes as follows:

> As I understand it, the validity of *Anancus* turns on Lartet's determination of the species as a synonym of *Mastodon arvernensis* in Bulletin Soc. Géol. France, Ser. 2, Vol. XII [XVI], p. 493, 1859. The date of the genus as a valid name would, therefore, date from 1859 or whatever year its connection with *M. arvernensis* was established. The identity of *Anancus macroplus* and *M. arvernensis* seems to be beyond question, in which case the type species becomes *M. arvernensis*. The type of a species is the specimen on which the species was based, but the type of a genus is the species on which the group is based. Only in monotypic genera would the same specimen be the type both of the species and the genus.

Proposal of the Generic Term Anancus based on Anancus macroplus

The extremely involved history of this generic term and of the various species related to it is kindly given by Dr. Lucien Mayet as follows:

Notes (Dr. Lucien Mayet, Lyon, France, December 11, 1922). "La question *Anancus macroplus* Aymard reste imprécisée: ce terme synonyme de *Mastodon arvernensis* Croizet et Jobert, ne parait véritablement pas pouvoir être conservé en l'absence de toute figure ou description détaillée. *Anancus macroplus* Aymard = *Mastodon arvernensis* Croizet et Jobert.

Aymard a multiplié les noms spécifiques pour les débris de Mammifères qu'il recueillait dans les nombreux gisements de la région du Puy-en-Velay. Isolé comme il l'était dans cette petite ville, travaillant à une époque où la paléontologie était encore une science extrêmement jeune cette surabondance de noms d'espèces s'explique aisément. La plupart de ces noms étaient inscrits simplement sur les pièces de la collection d'Aymard, ils ont pu être reproduits dans des listes dressées d'après cette collection (Musée Crozatier, au Puy) mais ils ne correspondent pas, en général, à des animaux décrits et figurés. En ce qui concerne plus spécialement *Anancus macroplus* Aymard avait appliqué ce nom à des ossements et à des dents d'un Mastodonte adulte le *Mastodon arvernensis* dont Croizet et Jobert n'avaient figuré que des dents de lait. Il n'y a aucun doute: les pièces étiquettées *Anancus macroplus* sont bien des débris de *M. arvernensis*. La première indication bibliographique qui est généralement donnée pour l'*Anancus macroplus* est: Bulletin de la Société géologique de France IV. 1. 11 janvier, 1847, pp. 414–415.

[*Mastodon vellavus*] Or le nom d'*Anancus macroplus* n'y est pas écrit: 'M. Aymard signale ensuite un Mastodonte surpassant de ⅛ le *Mastodon maximus* de l'Ohio, d'après un quatrième métartarsien, long de 0,255, large en haut de 0,110, en bas de 0,145, et ayant 0,095 dans son moindre diamètre. Il propose pour cette espèce le nom de *Mastodon vellavus*.' (*M. vellavus* Aymard = *M. Borsoni* Hays).

(*M. arvernensis* désigné par Aymard *Anancus macroplus*) 'Un métacarpien de l'annulaire long de 0,152, large de 0,072 en haut, 0,080 en bas, et 0,052 au milieu; deux arrières-molaires à huit pointes, longues de 0,167 et larges de 0,096, à mamelons comme dans celui de l'Ohio, indiquent une autre espèce, probablement la même que M. Bravard a signalée, peut-être à tort, comme ayant aux deux mâchoires une arrière-molaire à dix pointes précédée d'une molaire à six pointes; car l'auteur pense que cette formule aurait été déduite d'une arrière-molaire inférieure entière, et seulement d'une portion de mâchelière supérieure.'

(*M. Vialetii* Aymard = *M. Borsoni* Hays) Un autre Mastodonte plus petit que le précédent de ⅛: *Mastodon Vialetii*.

On cite ensuite comme référence bibliographique: *Anancus macroplus* Aymard. Annales de la Société d'Agriculture, Sciences et Arts du Puy. 1854 [1855], p. 597 [507]. Il s'agit d'une simple liste, sans description ni

figure. Il semble donc que la dénomination *Anancus macroplus* ne puisse pas être conservée, ni remplacer celle antérieure de *Mastodon arvernensis* Croizet et Jobert."

Summary by Osborn, 1924: From this analysis by Mayet of the literature and history, and from the examination by Palmer of the literature available to him in the preparation of his "Index Generum Mammalium" cited above, as well as by the researches of the present author, four points are established as follows:

(1) The specific type of *Anancus macroplus* Aymard from Mt. Coupet, Puy-en-Velay, is regarded as belonging to the same species as the type of *Mastodon arvernensis* Croizet and Jobert, from Auvergne, France.

(2) The genus and species *Anancus macroplus* Aymard, 1855, 1859, were applied to bones and teeth of an adult mastodont similar to that which Croizet and Jobert described and figured as *Mastodon arvernensis* from Auvergne, based on the milk dentition.

(3) In 1847 Aymard described and based the name *Mastodon vellavus* on a type which is now regarded as belonging to the same species as *Mastodon borsoni* Hays; also a second species *Mastodon Vialetii* which is now considered as equivalent to *M. borsoni* Hays. Thus from the standpoint of systematic description, the five species of Gervais and de Serres, Aymard, and Jourdan stand as follows:

Original Name	Specific Reference in Present Memoir
1846 *Mastodon brevirostre* Gervais and de Serres	= *Anancus arvernensis brevirostris*
1847 *Mastodon vellavus* Aymard	= *Zygolophodon borsoni vellavus*
1847 *Mastodon Vialetii* Aymard	= *Zygolophodon borsoni vialetii*
1855, 1859 *Anancus macroplus* Aymard	= *Anancus arvernensis macroplus*
1858 *Mastodon dissimilis* Jourdan	= *Anancus arvernensis dissimilis*

(4) To Osborn's mind the validity of the generic name *Anancus* depends upon the type specimens from Mt. Coupet, Puy-en-Velay, on which the species *Anancus macroplus* was based. These specimens, according to Doctor Mayet and others, are specifically identical with specimens referred to *Mastodon arvernensis*.

Consequently the genus *Anancus* rests upon the species *Anancus macroplus* Aymard, 1855, 1859, which is probably identical or synonymous with the prior named species *Mastodon arvernensis* Croizet and Jobert, 1828; for this reason (*fide* Lartet, 1859, p. 493) *Mastodon arvernensis* is cited throughout this chapter as the genotypic species.

3. CHARACTERS AND GEOLOGIC DISTRIBUTION OF THE SPECIES OF ANANCUS

Anancus arvernensis Croizet and Jobert, 1828

Figures 582, 584, 585, 588, 591, 595, 596, 601, 602, and 621

Upper Pliocene of Perrier, Auvergne, France (type of *Mastodon arvernensis*); of Montpellier (type of *Mastodon brevirostre*); of Puy (type of *Anancus macroplus*); of valley of the Saône (type of *Mastodon dissimilis*).

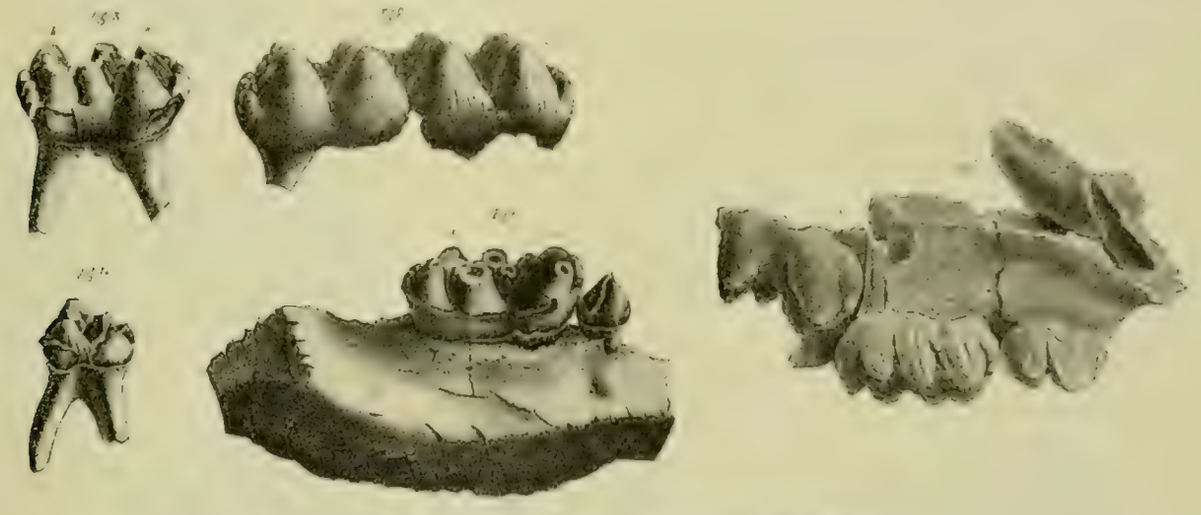
Syn.: 1846, *M. brevirostre* Gervais and de Serres, Montpellier, France.
1855, 1859, *Anancus macroplus* Aymard, Puy-en-Velay, France.
1858, *Mastodon dissimilis* Jourdan, valley of the Saône.
1922, *Mastodon minutoarvernensis* Klähn (see p. 283 of present Memoir).
1922, *Mastodon gigantarvernensis* Klähn (see p. 283 of present Memoir).

The cotypes of *Anancus arvernensis* are in a stage of evolution similar to that of the types of *Mastodon brevirostre*, of *Anancus macroplus*, and of *Mastodon dissimilis;* consequently these three species may prove to be synonyms. The crowns of the cotype grinders are extremely brachyodont and simple (cf. Figs. 596, 597). They are far more primitive than those of specimens found in the Red and Norwich Crags of England (Figs. 586 and 587) and erroneously *referred* to *M. arvernensis;* these Crag specimens belong to the far more progressive new species *Anancus falconeri* Osborn.

Mastodon arvernensis Croizet and Jobert, 1828. "Recherches sur les Ossemens Fossiles du Departement du Puy-de-Dome," pp. 133–138. Cotypes.—Cotype deciduous molars together with fragments of upper and lower jaws. Horizon and Locality.—Perrier, Auvergne, France; Upper Pliocene. Cotype Figures.—*Op. cit.*, Pl. I, figs. 1–4, Pl. II, fig. 7.

Original Description.—(Croizet and Jobert, 1828, p. 133): Comparing the cotypes with the species previously described by Cuvier, e.g., "le grand mastodonte," "le mastodonte à dents étroites," "le mastodonte des Cordilières," "le mastodonte humboldien," and "le petit mastodonte": "Il suffit de jeter un coup d'œil sur la mâchoire supérieure (fig. 7, pl. II), pour se convaincre

qu'elle a appartenu à un mastodonte; la dent mamelonnée à six pointes, et la forme de la mâchoire, en avant de la première molaire, ne peuvent laisser aucun doute à cet égard. . . . Comme l'animal est très-jeune, la dent à quatre pointes est évidemment la première, . . . M. Bravard, qui n'avait pas senti dans le premier moment, l'importance de réunir les deux fragmens, s'aperçut plus tard qu'il était essentiel de les donner ensemble; et, comme il s'était, selon toute apparence, assuré qu'ils s'ajustaient parfaitement, il les reproduisit dans la figure 4 (pl. 1). . . . . La figure 2 (pl. 1) paraît être une première molaire supérieure; elle appartenait probable-



Juvenile Cotype Molars of Anancus arvernensis

Fig. 596. Deciduous cotype molars of *Mastodon arvernensis* Croizet and Jobert, 1828, Pl. 1, figs. 1–4; Pl. II, fig. 7: "Pachydermes Fossiles de la Montagne de Perrier." One-half natural size. (Croizet and Jobert, 1828, p. 221): "Planche 1. Fig. 1. Mâchoire inférieure de mastodonte [pp.] 134, 136. Fig. 2. 1re Molaire de mastodonte [p.] 136. Fig. 3. Molaire à six pointes, de mastodonte [pp.] 134, 136. Fig. 4. Molaire à huit pointes [pp.] 135, 141. . . . Planche II . . . Fig. 7. Mâchoire supérieure de mastodonte [pp.] 133, 135, 141."

ment au même individu que la mâchoire inférieure, figure 1; elle a été trouvé à côté, de celle-ci, . . . Il doit donc être parfaitement démontré, soit par les formes, soit par les dimensions des molaires et même par les os des jambes, que nous avons trouvé une nouvelle espèce du genre mastodonte; nous proposons de la distinguer sous le nom de mastodonte d'Auvergne, *mastodon arvernensis*."

Croizet and Jobert published on page 138 a comparative table of measurements of the grinding teeth, including the type r.M_2 of "Mastodonte à dents étroites," as follows:

Geologic Age, cf. Osborn, 1900.187, p. 33, 1922.563, pp. 437–439, and 1926.706, p. 13.—*Anancus arvernensis* and *A. falconeri* occur amidst the 'newer pleiocene fauna' of English authors, the 'faune pleiocène récente' of Depéret. *Hipparion* disappears, being replaced by *Equus stenonis; Rhinocerus etruscus* succeeds *R. leptorhinus. Macacus florentinus* appears related to the living Gibraltar form. The Proboscidea are represented by the last of the European mastodons, '*Mastodon*' [=*Anancus*] *arvernensis* and '*M.*' [=*Zygolophodon*] *borsoni*, also by three species of elephants, namely, *Elephas* [=*Archidiskodon*] *planifrons* (Chagny), the far more progressive *E.* [=*Archidiskodon*] *meridionalis*, and *E.* [=*Hesperoloxodon*] *antiquus ausonius.*

From the faunistic table of horizons below it would appear that the Norwich and Red Crags, containing the more progressive species *Anancus falconeri*, *Archidiskodon meridionalis*, and a very primitive stage of *Hesperoloxodon antiquus*, are geologically more recent than the type and other localities of the true *Anancus arvernensis*, namely, Perrier, Montpellier, Puy, and Chagny, in which latter locality occurs the more primitive species *Archidiskodon planifrons.*

	Mastodonte de l'Ohio.	Mastodonte à dents étroites.	Mastodonte des Cordilières.	Mastodonte Humboldien.	Mastodonte Petit.	Mastodonte Tapiroïde.	Mastodonte d'Auvergne.
Longueur....	0,110	0,116	0,120	0,080	0,079	0,078	0,053
Largeur.....	0,085	0,060	0,085	0,060	0,040	0,040	0,030

Étage Villafranchien (of Northern Italy)

Summit or close of the Pliocene (= Plio-Pleistocene transition) = St. Prestien of France.

England. Norwich Crag (Norfolk) Fluvio-marine. *M.* [=*Anancus*] *arvernensis* [=*Anancus falconeri*], *E.* [=*Archidiskodon*] *meridionalis*, *E.* [=*Hesperoloxodon*] *antiquus*.

Red Crag (Suffolk) Marine. *M.* [=*Zygolophodon*] *borsoni*, *M.* [=*Anancus*] *arvernensis* [=*Anancus falconeri*], *E.* [=*Hesperoloxodon*] *antiquus*. *E.* [=*Archidiskodon*] *meridionalis*, *fide* Lydekker, 1886.2, p. 113.

Italy. Olivola, a little higher than Val d'Arno. Summit of Pliocene.

Val d'Arno *supér.* Thick fluvio-lacustrine beds (60 meters). Fauna fully listed by Stefani. *E.* [=*Archidiskodon*] *meridionalis*, *E.* [=*Hesperoloxodon*] *antiquus ausonius*.

Astésan, Villafranca (San Paola), Tossano. *M.* [=*Anancus*] *arvernensis*, *E.* [=*Archidiskodon*] *meridionalis*.

Upper Pliocene

France. Sainzelles (Puy), a little higher than Perrier.

Perrier (Issoire) fluviatile gravels. Type of *M.* [=*Anancus*] *arvernensis*. *M.* [=*Zygolophodon*] *borsoni*.

Montpellier *supér.* (Rhône), fluvio-lacustrine. Type of *M.* [=*Anancus*] *brevirostre*.

Coupet *supér.*, volcanic deposits.

Chagny (Bellecroix), Saône, fluviatile clays and sands. *E.* [=*Archidiskodon*] *planifrons* (cf. Mayet, 1920); *M.* [=*Anancus*] *arvernensis*, *M.* [=*Zygolophodon*] *borsoni*.

Sables à Mastodontes du Puy, Coupet, Vialette. Type of *Anancus macroplus*.

Anancus arvernensis brevirostris Gervais and de Serres, 1846

Figure 597

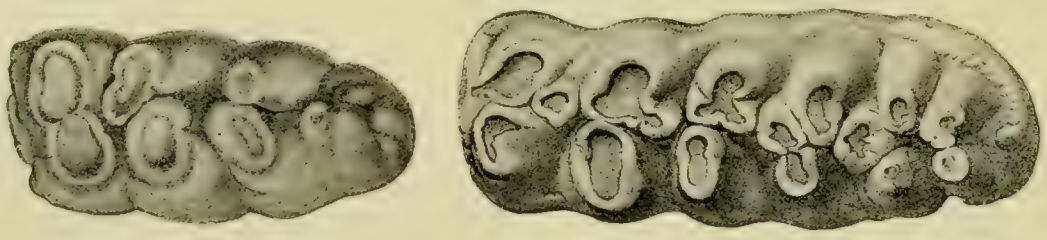
Upper Pliocene of Montpellier, Hérault, France.

Regarded by French authors as a synonym of '*Mastodon*' [=*Anancus*] *arvernensis;* until it is positively determined by monographic research that the *M.' brevirostris* of Montpellier is identical with the '*M.' arvernensis* of Auvergne, it seems best to retain this form as a subspecies of '*Mastodon*' [=*Anancus*] *arvernensis*.

Mastodon brevirostre Gervais and de Serres, 1846. "Sur les Mammifères dont on a trouvé les restes fossiles dans la caverne de Lunel-Viel et dans les sables de Montpellier." Ann. Sci. Nat., Paris, (3) V, p. 268. Cotypes.—Lower third inferior molars. Gervais in his supplementary description of this species states (1848–1852, p. 37): "J'ai établi cette espèce d'après un assez bon nombre de pièces, dont les unes avaient été attribuées au *Mastodon angustidens*, et les autres aux *Elephas primigenius* et *meridionalis*." Horizon and Locality.—Sables marins de Montpellier, Florensac, Soret near Montpellier, Hérault, France. Cotype Figures.—Gervais, 1859, Pl. I, fig. 3, and Pl. III, fig. 7 (same figures as in first edition of 1848–1852).

We do not know the exact type. Localities of the cotypes (Fig. 597) and of referred specimens are Montpellier and the Sables de Florensac (Hérault).

Original Description of Mastodon brevirostre.—Gervais and de Serres (1846, p. 268) first named this species as follows: "Mastodonte, *Mastodon.*—L'espèce que nous nommerons *Mastodon brevirostre* [Footnote: 'L'un de nous (M. Gervais) vient de constater dans la riche collection de M. Bravard qu'il y [avait] aussi en Auvergne un Mastodonte d'espèce particulière, ainsi que l'ont pensé les paléontologistes de ce pays. Un squelette presque entier, que M. Bravard vient de découvrir aux environs d'Issoire, ne permet plus le doute à cet égard. Le Mastodonte d'Auvergne se rapproche, par la forme de ses molaires et quelques autres particularités, que M. Bravard fera sans doute connaître prochainement, du *Mastodon tapiroides* de MM. Lartet et de Blainville, du *Mast. giganteum* et même, jusqu'à un certain point, du *Dinotherium.*'] nous paraît différer de celle du Gers, de l'Orléanais, de la Hesse, etc.; ses molaires étaient plus larges; sa mâchoire inférieure avait une symphyse courte, et non prolongée en gouttière allongée et armée de défenses: caractères que MM. Kaup et de Blainville ont reconnus à la mâchoire inférieure du *Mastodon angustidens* ou *longirostre.* Les incisives supérieures étaient néanmoins en forme de défenses, et garnies d'une bande étroite d'émail, comme chez le *Mastodon angustidens.* Les os de ce Mastodonte de l'Hérault sont assez fréquents; on les a pris quelquefois pour ceux de l'Éléphant, auxquels ils paraissent ressembler plus que ceux du Mastodonte miocène."



Two Cotype Inferior Molars of Anancus arvernensis brevirostris. After Gervais

Fig. 597. Two cotype specimens of *Mastodon brevirostre*, after Gervais, 1859, Pl. I, fig. 3, and Pl. III, fig. 7 (same figures as in first edition of 1848–1852). The following is cited from the edition of 1859, p. 66: (Left) Pl. I, Fig. 3: "Dernière molaire inférieure [broken l.M_3] du *Mastodon brevirostris;* des sables de Florensac (Hérault)." (Right) "Pl. III, Fig. 7 [au *tiers de grand nat.*]. Dernière molaire inférieure droite [r.m_3], trouvée auprès de la citadelle de Montpellier et donnée à la Faculté des sciences de cette ville, ainsi que la mâchoire inférieure de la figure 9, par M. le colonel du génie Vainsot." Compare this six+crested *right* inferior molar from Montpellier with the six+crested *left* inferior molar of *Anancus properimensis* sp. nov. (Fig. 613) from the Lower Chinji horizon of India. Right-hand figure one-third natural size (*fide* Gervais, *op. cit.*, p. 66). Observe *central conules* in three anterior valleys.

4. DISTINCTIONS OF ANANCUS ARVERNENSIS AND THE MORE PROGRESSIVE A. FALCONERI

Fig. 1

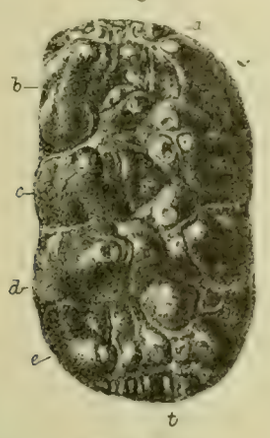


Fig. 2.

Fig. 3

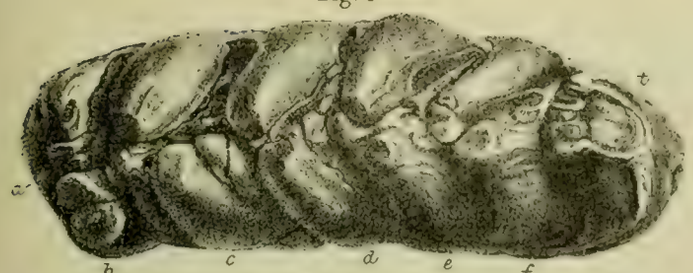
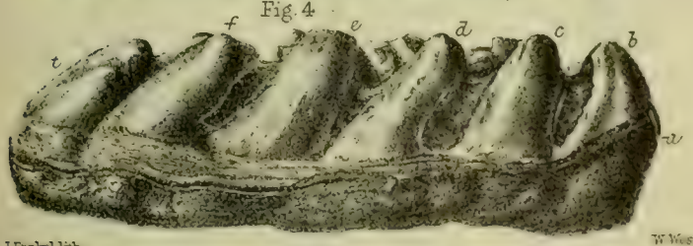


Fig. 4



Mastodon (Tetralophodon) Arvernensis, from the Crag.

TYPE OF ANANCUS FALCONERI (FIGS. 3 AND 4). AFTER FALCONER

Fig. 598. Referred *'Mastodon' (Tetralophodon) arvernensis* from the Crag [Red Crag and Nodule bed], England. Reproduced same size from Falconer's "Palæontological Memoirs," 1868, Vol. II, Pl. IV. About two-ninths natural size. Fig. 1. From Ramsey, near Harwich [Essex]; . . . "germ of the penultimate true molar from the right side of the upper jaw." Fig. 2. Same tooth in profile. Fig. 3. From Suffolk; . . . "the last true molar from the left side of the lower jaw. (See page 31.) *b, c, d, e, f*, the five ridges composing the crown, the mammillæ of which are disposed alternately." Similar to a molar regarded as an M^3 by Cuvier (see Falconer, *op. cit.*, p. 31); cones inclined strongly *forwards*. Fig. 4. Same tooth in profile.

The tooth (Figs. 3, 4) was selected by Osborn (Osborn, 1926.706, pp. 13, 14) as the type of a new species, *Anancus falconeri*, named in honor of Dr. Hugh Falconer. Figures 1 and 2 equal *Anancus falconeri* ref.

Comparison of the type specimens of *Mastodon arvernensis* (Fig. 596) and of *M. brevirostre* (Fig. 597) with the subhypsodont and more progressive specimens from the Red Crag of Suffolk and Nodule bed of Ramsey (Fig. 598) proves that Falconer erred in placing these specimens in the same species with the specimens of *'M.' arvernensis* from Auvergne and Montpellier. While they exhibit the same ridge formula, namely, M 3 $\frac{5\cdot5}{5\cdot5}$, the specimens from the Red Crag of Suffolk belong to a more progressive stage of evolution to which the new specific name *Anancus falconeri* has been applied (Osborn, 1926.706, p. 13). Nevertheless Falconer's observations and notes constitute the first clear generic definition and distinction of species of *Anancus* from species belonging to *Trilophodon* and *Tetralophodon*, as shown in the following citations.

FALCONER (1868), GEOLOGIC AGE.—*'Mastodon' (Tetralophodon) arvernensis* (Falconer, 1868, II, pp. 26–64). Falconer's comparisons led to the following conclusions (p. 64): "1. That the Mastodon remains which have been met with in the 'Fluvio-marine Crag' and 'Red Crag' belong to a Pliocene form, *Mastodon (Tetralophodon) Arvernensis*. 2. That the Mammalian Fauna of the Fluvio-marine Crag bears all the characters of a Pliocene age, and is identical with the Sub-Apennine Pliocene Fauna of Italy. 3. That the Red and Fluvio-marine Crags, tested by their Mammalian Fauna, must be considered as beds of the same geological age."

Osborn, 1924: It proves (1) that Falconer erred in including within the same species the *'M.' arvernensis* of Italy and the specimens from the Red Crag of England; (2) that the English Red Crag specimens are far more progressive and belong to the more progressive species *Anancus falconeri*. (3) Consequently, the Red Crag of England is more recent geologically than the Upper Pliocene beds of Auvergne, in which occur the cotypes of *'M.' arvernensis*.

GENERIC AND SPECIFIC CHARACTERS (FALCONER, 1865, P. 262; 1868, PP. 24–64).—Besides describing the two skeletons of *'M.' arvernensis* in the Turin and Bologna museums (Figs. 584 and 585 respectively) Falconer distinguishes the species *'M.' arvernensis* from *'M.' longirostris* and *'M.' angustidens*, with which it had been confused, by the following characters:

(1) M^3 with five ridges, an anterior 'talon,' and a strong back 'talon,' each ridge consisting of two pairs of thick, high, conical mammillæ, with very thick enamel; the inner and outer mammillæ alternating not opposing; the valleys interrupted with one or more large accessory conical mammillæ, which wear into *alternate* trefoil discs, instead of the single or double transverse discs of *M. longirostris* and *M. angustidens*, in which the discs are always opposite. (2) *Mastodon sivalensis* of India is most nearly allied to the English Crag Mastodon, but differs in the ridge formula:

'Mastodon' sivalensis M 2 $\frac{5}{5}$ M 3 $\frac{6\cdot6}{}$ [=*Pentalophodon sivalensis* Caut.].

'Mastodon' arvernensis M 2 $\frac{4}{4}$ M 3 $\frac{5\cdot5}{5\cdot5}$ [=*Anancus falconeri* Osb.].

(3) *M. sivalensis* exhibits a greater amount of alternation of the crown mammillæ and more complexity of pattern than is even seen in the English Crag Mastodon. (4) [Superior] cones subhypsodont, compressed at the summit, strongly inclined backwards; M_3 extremely elongate [cones inclined forwards], 8½ in.

× 3 in. (Crag of Suffolk), 9½ in. × 3¼ in. (Montpellier). (5) "The ridge-formula in the molar teeth of the Crag Mastodon, including milk and true molars, but exclusive of premolars, as inferred from the various data detailed in the previous pages, is—Milk molars $\frac{2+3+4}{2+3+4}$. True molars $\frac{4+4+5}{4+4+5}$" (*op. cit.*, 1868, II, p. 39).

FALCONER'S NOTES OF 1868 ON MASTODON [=ANANCUS] ARVERNENSIS [=ANANCUS FALCONERI, NORWICH AND RED CRAGS]

"Palæontological Memoirs" Vol. I, 1868, pp. 467, 468, Pl. XXXVI

Mastodon arvernensis Croizet and Jobert, 1828, Pl. I, figs. 1–4, Pl. II, fig. 7.

(1) UPPER JAWS.—Plate XXXVI, figures 7, 7*a*, English [Norwich] Crag, upper jaw with Dp^4, ridges ½–4–½. (Falconer, *op. cit.*, p. 467) "The crown is composed of four ridges with a front and hind talon, and a well-pronounced basal 'bourrelet.' The three anterior divisions are more or less worn, especially along the inner side; the last ridge is nearly intact. The ridges are connected by one or two stout conical mammillæ, interrupting their transverse continuity, and alternating with the divisions of the main ridges." Figures 8, 8*a* [Norwich Crag], upper jaw, r.M^3, ridges ¼-5-½ "composed of five ridges with an anterior talon, and a strong back talon," valleys interrupted by accessory conical mammillæ, deep clefts between the ridges; figures 9, 9*a* [?Red Crag], upper jaw, l.M^3, ridges 5½. "The crown consists of five ridges and a heel ridge of four points. . . . The enamel is very thick. . . . The second and third ridges are very closely approximated, with but one intermediate mammilla." (2) According to the above notes, the formula of *Mastodon arvernensis* of the Norwich and Red Crags is as follows:

Falconer (1868), type ridge formula of *M. arvernensis* [=*A. falconeri*]: Dp 4 $\frac{½-4-½}{}$ M 3 $\frac{¼-5-½}{}$.

Osborn, 1924: As remarked above, Falconer determined that the specimens from the Red Crag of Suffolk, and from the Norwich Crag of Norfolk, East Anglia (compare Osborn, 1922.563, p. 437) exhibit the same ridge formula, namely, M 3 $\frac{5½}{5½}$, as the specimens of *Mastodon arvernensis* from Auvergne: he accordingly placed them in the same species, because he was strongly impressed with the value of ridge formulæ. Thus '*Mastodon*' *arvernensis* has been recorded by all subsequent writers, e.g., E. T. Newton (1890), R. Lydekker (1886), and Osborn (1922.563, pp. 436, 437), as occurring both in the Red Crag and in the overlying and somewhat more modern Norwich Crag. The old correlation of the Red Crag with the Upper Pliocene Val d'Arno *supér.* of northern Italy is *erroneous*; the specimen figured by Falconer (Fig. 598), and by Osborn (Fig. 599) as the type of the more progressive species *Anancus falconeri*, are described by Falconer and Lydekker as from the [Red] Crag of Suffolk; they are certainly much more progressive in form than the typical '*M.*' [=*Anancus*] *arvernensis*, '*M.*' [=*Anancus*] *brevirostris*, of France, etc.

Anancus falconeri Osborn, 1926

Figures 586, 587, 598, 599

Uppermost Pliocene, Red or Norwich Crag of Suffolk, England.

Comparison of the type figures (Figs. 598, 599) of *Anancus falconeri* will leave no doubt of its complete separation from *A. arvernensis* (see Fig. 596). The species is named in honor of Sir Hugh Falconer.

HISTORY.—This specific stage is distinguished from the typical *Anancus arvernensis* of Auvergne by the striking subhypsodonty of the crowns of the grinding teeth and by the close compression of the summit of the crowns, although the ridge formula, namely, M $3\frac{5½}{5½}$, is the same as in the type of *Anancus arvernensis*. This progressive stage of *Anancus*, which belongs at the very close of the British Pliocene as found in the Red Crag and in the somewhat more recent Norwich Crag, was originally described by Owen as *Mastodon angustidens* (Owen, 1846, pp. 271–298), and by Falconer as *Mastodon* (*Tetralophodon*) *arvernensis* (Falconer, 1857, pp. 321–360, Pl. XII; 1868, Vol. II, pp. 26–64, Pl. IV).

Anancus falconeri Osborn, 1926. "Additional New Genera and Species of the Mastodontoid Proboscidea." Amer. Mus. Novitates, No. 238, November 30, 1926, pp. 13, 14. TYPE.—. . . "last true molar from the left side of the lower jaw," from the Red or Norwich Crag of Suffolk, England. Cast in Museum of Geological Society of London. HORIZON AND LOCALITY.—Uppermost Pliocene, Red or Norwich Crag of Suffolk, England. TYPE FIGURE.—Originally described and figured as *Mastodon* (*Tetralophodon*) *arvernensis* from the Crag (Falconer, 1857, Pl. XII, figs. 3 and 4, and "Pal. Mem.," Vol. II, 1868, Pl. IV, figs. 3, 4; Osborn, 1926.706, p. 14, fig. 12; reproduced herewith (Figs. 598 and 599).

TYPE CHARACTERS.—(Osborn, *op. cit.*, 1926.706, p. 14): "In the five and a half ridges composing the crown, the cones are disposed alternately; the inferior cones are inclined strongly forwards, closely compressed at the summits, subhypsodont in height. Distinguished from the typical *Mastodon arvernensis* Croizet and Jobert, 1828, by the elevated, subhypsodont cones, strongly compressed at the summits [Figs. 599 and 586], and by the plicated or folded enamel of the milk dentition [Fig. 587]. Ridge formula: M 3 $\frac{5½}{5½}$."

Fig. 3

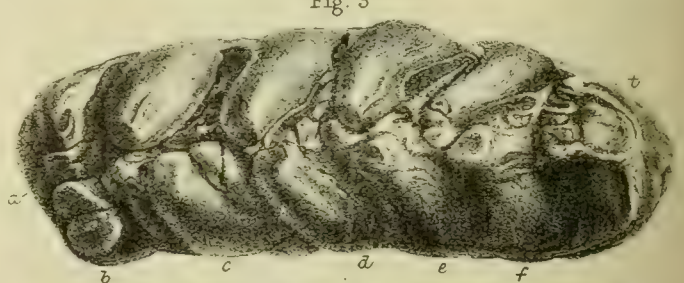
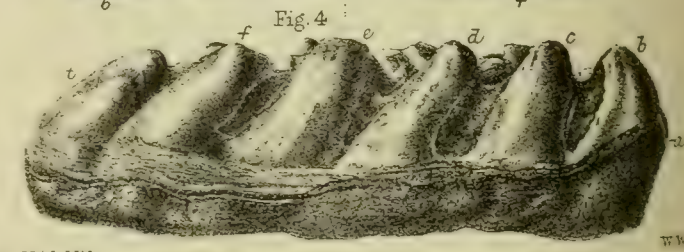


Fig. 4



G.H.Ford del. J.Dinkel lith. W.W.S

Mastodon (Tetralophodon) Arvernensis, from the Crag.

TYPE OF ANANCUS FALCONERI. AFTER FALCONER

Fig. 599. Type left third inferior molar, l.M_3, of *Anancus falconeri* Osborn, 1926. Uppermost Pliocene, Red or Norwich Crag of Suffolk, England. Cast in the Museum of the Geological Society of London. After Falconer, 1868, Vol. II, Pl. IV, figs. 3 and 4, determined by Falconer as a third inferior molar of the left side, l.M_3. About two-ninths natural size. Compare with the six+crested third inferior molar of the left side of *Anancus properimensis* sp. nov. of the Siwaliks, India (Fig. 613).

5. ANANCUS ARVERNENSIS OR A. FALCONERI IN ITALY; ANANCUS IN GERMANY

It is difficult to determine from the figures and descriptions accessible to Osborn whether the specimens described as '*Mastodon*' *arvernensis* from northern Italy agree more closely with the type of this species from Auvergne, or with the more progressive type which we have named *Anancus falconeri* from the uppermost Pliocene Crag of Suffolk, England. From the figure published by Sismonda in 1851 (see Fig. 600), it would appear that this specimen at least approaches the more progressive stage of *A. falconeri*.

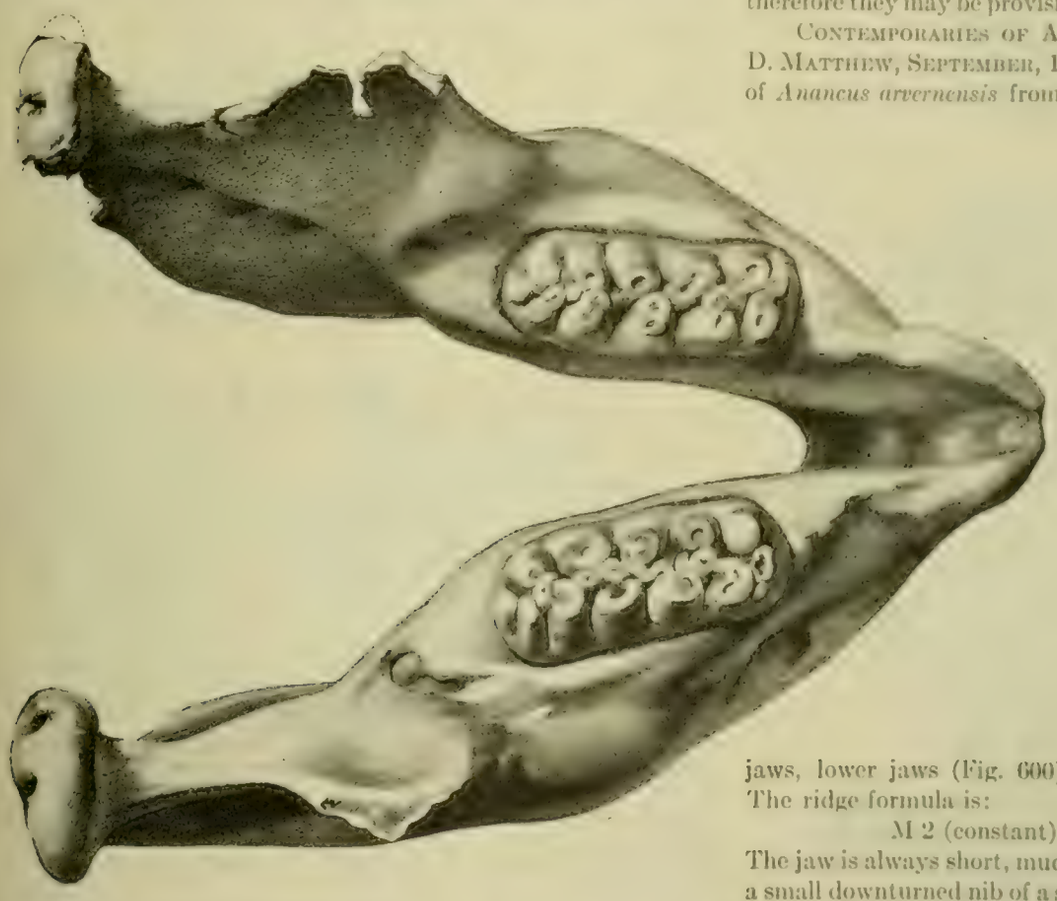


FIGURE OF THE LOWER JAW (CROWN VIEW) OF ANANCUS ARVERNENSIS (?)

Fig. 600. Lower jaw of '*Mastodon*' *angustidens* described and figured by Eugenio Sismonda in his memoir of 1851, "Osteografia di un Mastodonte Angustidente," Tav. I, fig. 3. In the same plate are figured a side view of the palate and lower jaw (Fig. 1); the palate with M^3 (Fig. 2), and the grooved tusks (Figs. 4, 5). Portions of the vertebral column are figured in Tav. II; of the fore- and hindlimbs in Tav. III; of the ribs in Tav. IV, and of the pelvis in Tav. V. An excellent restoration of the parts preserved is given in Tav. VI (see Fig. 584 of the present Memoir). Original with a rich collection of Asti specimens in the Turin Museum. One-fifth natural size.

These specimens therefore for the present may all be referred to as *Anancus arvernensis*.

SISMONDA, 1851.—In his Memoir of 1851, Eugenio Sismonda described a finely preserved lower jaw, which he referred to *Mastodon* [=*Trilophodon*] *angustidens*, under the title "Osteografia di un Mastodonte Angustidente." It is not surprising that Sismonda referred this animal to Cuvier's species *Mastodon angustidens* because the beautifully preserved molars display single trefoils in the center of the valleys; he did not observe the marked alternation of the cones. The ridge formula in this superb specimen should be written: M 3 $\frac{\overline{5-6}}{5}$, because it is apparent that the molar tooth on the right side is somewhat more progressive than that on the left, that the fifth crest or pentalophid is not so fully developed as the previous ridge-crests, and that there is a little spur representing the sixth crest behind the fifth.

The original Sismonda skeleton (Fig. 584) in the Turin Museum is crushed and incomplete, including the tusks, the lower jaws (Fig 600), and the upper teeth; the bones are fragmentary, although largely present; the individual is not of large size, but it is regarded unquestionably as *Anancus arvernensis*, not as *Mastodon angustidens* as reported by Sismonda.

Comparison of the third inferior molar teeth of this beautiful specimen (Fig. 600) shows that they are slightly more primitive than the type of *Mastodon brevirostre* Gervais and de Serres (Fig. 597); therefore they may be provisionally referred to *Anancus arvernensis*.

CONTEMPORARIES OF ANANCUS ARVERNENSIS IN ITALY (W. D. MATTHEW, SEPTEMBER, 1920; TURIN MUSEUM).—A fine series of *Anancus arvernensis* from the Pliocene of Asti includes upper jaws, lower jaws (Fig. 600), and various parts of the skeleton. The ridge formula is:

M 2 (constant) 4½: M 3 (variable) 5½-6½

The jaw is always short, much as in *Mastodon americanus*, but with a small downturned nib of a symphysis; the pelvis is much broader than in *Elephas*, but hardly as wide as in *M. americanus*.

A considerable portion of a skeleton was found in 1904; the tusks have a lyrate curve, somewhat similar to those of *Stegodon* and of *Loxodonta antiqua* [=*Hesperoloxodon antiquus*]; one tusk is nearly 10 feet in length. Associated with this mastodon, as in other collections, is a fine skeleton of *Rhinoceros etruscus* var. *astensis*, an animal with proportions somewhat similar to those of *R. bicornis*, but shorter in the body and longer in the limbs.

ANANCUS IN GERMANY

Anancus minutoarvernensis Klähn, 1922

Anancus gigantarvernensis Klähn, 1922

In 1922, Dr. Hans Klähn described the above new subspecies of *Mastodon arvernensis* from Herbolzheim, southern Baden, Germany. A brief mention of these mastodonts is made in Chapter VIII, p. 283, of the present Memoir.

6. ANANCUS IN HUNGARY, IN VOLHYNIA AND BESSARABIA, RUSSIA, AND IN CHINA

Schlesinger, 1922, pp. 61–76.—From the Hungarian collection at Budapest, Schlesinger describes very numerous remains from various parts of Hungary which he refers to *Mastodon (Dibunodon) arvernensis* and which he figures in detail in his invaluable Memoir, including a superior milk molar, r.Dp^4, and a right superior molar, r.M^1 (Taf. x, fig. 7, xi, fig. 3) from the Levantin lignites of Barót, also an r.M^2 from near Budapest (Taf. xi, fig. 7), a tooth

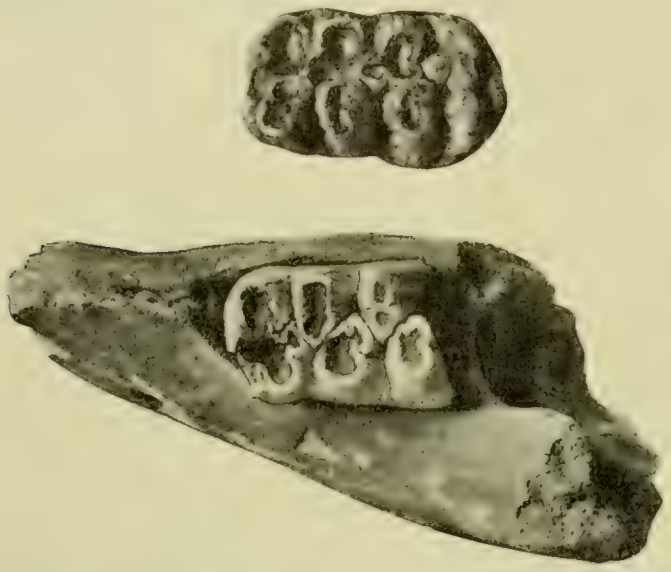


Fig. 601. Referred grinding teeth of *Anancus arvernensis*, after Schlesinger, 1922, Taf. xi, figs. 4 and 8, one-third natural size. The molar shown in figure 4 (upper) is from Ajnácskö, Komitat Gömör, Hungary, that in figure 8 (lower) from Rákoskeresztúr, Komitat Pest, Hungary.

Observe prominent single trefoils on *external* cones below (l.M_1) and on *internal* cones above (r.M^1).

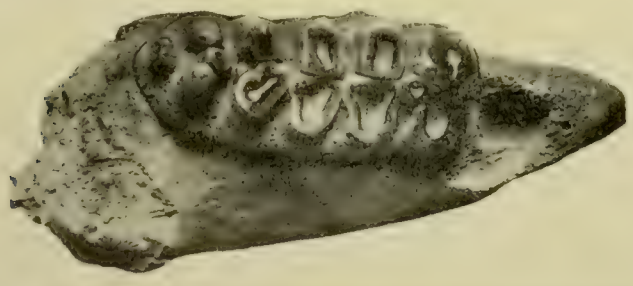
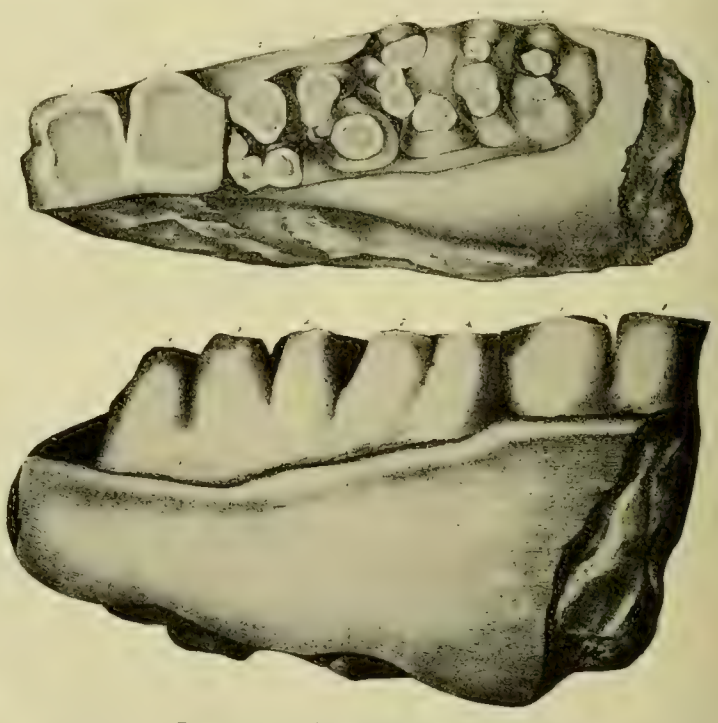


Fig. 602. Referred right inferior grinding tooth, r.M_3, of *Anancus arvernensis*, after Schlesinger, 1922, Taf. xiii, fig. 2, one-third natural size. From Ajnácskö, Komitat Gömör, Hungary.

Observe five and a half ridge-crests, very simple intermediate conelets, relatively slight alternation of the cones, resembling grinders of *A. perimensis* (cf. Fig. 606 of present Memoir.)

which might be referred to *Tetralophodon longirostris*. Unmistakable *Anancus arvernensis* molars are an r.M^1 and an l.M_1 (Taf. xi, fig. 4 and fig. 8—Fig. 601 of the present Memoir) from Ajnácskö and Rákoskeresztúr, of Levantin or Middle Pliocene age; the present author also reproduces herewith (Fig. 602) an r.M_3 (*op. cit.*, 1922, Taf. xiii, fig. 2) resembling the corresponding tooth of *Anancus perimensis*. Schlesinger speaks (*op. cit.*, pp. 69 and 70) of the superb materials from these localities. The cranium (*op. cit.*, p. 71) he describes as follows: "Schädel lagen mir leider nicht vor, doch ist die Form des Craniums aus früheren Publikationen (vgl. L.-V. 27, S. 134–136 und S. 139–141) hinlänglich bekannt geworden. Von *M. longirostris* unterscheidet es sich, soweit dieses bekannt ist, durch die bedeutende kegelförmige Zuspitzung des Domes, das elefantenartige Hervortreten der die Molaren tragenden Knochenbüchsen und die Form und Grösse des Stosszähne. Letztere waren bei *M. arvernensis* im Vergleich zum kurzen Schädel lang und schlank, lyraförmig geschwungen und strebten von der Inzisoral-



Paratype of Anancus intermedius

Fig. 603. Paratype or referred specimen of *Mastodon intermedius* Eichwald, 1831, found in Volhynia, Russia, on the confines of Austria. After Eichwald, 1835, Tab. lviii (inner view of jaw), Tab. lix (crown view of M_2, M_3), reduced to one-third natural size.

The figured jaw may be regarded as a paratype, containing M_2, M_3, with a five-lobed third inferior molar, the crown view of which is fairly well figured by Eichwald. The crown view shows the internal and external cones strongly alternating, as in *Pentalophodon sivalensis* and *Anancus arvernensis*, with indications of accessory mamillæ or conules. The long, narrow proportions agree closely with those in the type specimen of *P. sivalensis* Cautley (cf. Fig. 616 of the present Memoir), the length being two and a half times the width.

veole an in sanftem Bogen nach aussen, um sich ungefähr vor der Mitte ihrer Länge einander wieder zu nähern."

As to the widespread distribution of this species he concludes (*op. cit.*, pp. 73 and 75): "Ebenso wie die Verbreitung des *M. arvernensis* überhaupt eine ausserordentlich ausgedehnte war (vgl. L.-V. 27, S. 142), so wurde die Form im besonderen auch in Ungarn an zahlreichen Stellen gefunden. Die meisten Reste hat Ajnácskö im Komitate Gömör geliefert. Von dort konnten wir obere Inzisoren, Mandibeln und zahlreiche Molaren (M^1, M^2, M^3, M_1 und M_3, alle in mehreren Stücken) bekanntmachen. Die Matrix ist

ein rostroter Sand und Schotter, der mehrere andere Säugerreste geliefert hat, mit welchen wir uns im geologisch-stratigraphischen Teil dieser Arbeit ja noch eingehend zu beschäftigen haben werden. Wesentlich ist, dass Elefantenreste nicht gefunden wurden. Alle diesbezüglichen Feststellungen sind Irrtümer. Ich komme darauf noch zurück. . . . In diesen Schottern, über deren oberpliozänes Alter nicht der geringste Zweifel herrschen kann, fand sich keine Spur von *M. arvernensis*. Es ist daher naheliegend, die reguläre Verbreitung dieser Art in Ungarn auf das Levantin zu beschränken. Dies umsomehr, als sich auch in den übrigen, über dem Levantin gelegenen Horizonten, selbst wenn sie Fossilreste von Wirbeltieren geliefert hatten, nie *M. arvernensis* fand."

Anancus intermedius Eichwald, 1831

Figure 603

Volhynia, Russia, on the confines of Austria. Probably Pliocene.

This animal, which appears to be closely related to the *Anancus arvernensis* stage of western Europe, was admirably described by Eichwald in a long Latin sentence in the "Zoologia Specialis," 1831, pp. 361, 362. De Blainville (1839–1864, p. 253) gives the following reference: "Eichwald, 1831, *Zool. Spec.*, III, p. 341 [361]." Lydekker does not mention this species.

M. [*Mastodon*] *intermedius* Eichwald, 1831. "Zoologia Specialis," Vol. III, 1831, pp. 361, 362. TYPE AND PARATYPE.—Since Eichwald designates as the type "unicum maxillæ superioris, (non inferioris, . . .)," the figured jaw (Fig. 603) may be regarded as a paratype. HORIZON AND LOCALITY.—Volhynia, Russia, on the confines of Austria. PARATYPE FIGURE.—*Type* described as "unicum maxillæ superioris, (non inferioris, . . .)." Consequently the inferior maxilla and molars M_2, M_3 (Eichwald, 1835, Pls. LVIII, LIX) belong to a *paratype* or *referred* specimen and not to the type. We have not found a figure of the type maxilla, which is, however, admirably described in the following sentence:

TYPE DESCRIPTION.—(Eichwald, 1831, pp. 361, 362): "3. *M. intermedius*, m., colliculis transversis postremi dentis molaris superioris maxillæ 5, regularibus seriebus dispositis, accessoriis conulis inter postremas nullis, areis detritorum eorundem teretibus, nec quadratis. Hab. fossilis in Volhynia; fragmentum, quod servatur in collect. oryct. Lycaei Kremenec., unicum maxillæ superioris, (non inferioris, ut dicitur vitio scriptorio in opere meo: Skizze *l. c.* p. 239) pedale, dentibus 2 molaribus instruitur, quorum alter posticus fere 6 poll. longus, ultra 2 latus est, series 5 transversæ colliculorum plus minus detritorum bene conspicuæ, areæ istæ nec rhombos, nec angulata quadrata (*gall. trefles*) constituentes, at teretes, aut angulato-rotundatæ; postremæ seu primæ seriei colliculi duo approximati, minimi, conici, parum detriti, secundæ illi majores, distantes, laterales, intermediis aliis 2 intercedentibus plane evanidis, tertiæ dein seriei colliculi 4 in semicirculo versus posteriora hiante dispositi, extremis 2 majoribus, intermediis multo majoribus, quartæ demum et quintæ seriei, ipsius itaque anticæ colliculi maximi, duobus in qualibet sitis lateralibus, intermediis exiguis non completis, tanquam accessoriis, in interstitiis illorum obviis, omnibus detritis, areas rotundatas proferentibus; pars maxillaris ipsa ab exteriore conspecta, colliculos singulos pollice latiores multoque longiores offerens, intermediis magis distantibus quam extremis, his in ipso apice adjugatis. Anterioris alterius dentis soli 2 colliculi mammillares plane detriti ac fracti cognoscuntur. E fragmento hoc maxillari animal formæ certe giganteæ prodit."

Osborn, 1924: The measurements taken from Eichwald's figures (Fig. 603) are: M_3, length of crown 161 mm., width of crown 64 mm., index 40. The ridge formula is: M 3 $\frac{---}{5.5}$, that is, in front of the protolophid there are two small conelets, then follow the proto-, meta-, trito-, and tetartolophids, the pentalophid consisting of two compressed cones; the tritolophid consists of four conelets. The actual relationships of this crown either to *Anancus arvernensis* or to certain Siwalik species cannot be determined.

Anancus arvernensis progressor Khomenko, 1912

Figure 604

From near Gavanosy, district of Ismail, southern Bessarabia, Russia. Probably Pliocene.

This progressive Brevirostrine is of interest because of its occurrence in southern Russia, half way between the Brevirostrines of France and of India. The ridge formula is apparently M 2 $\frac{---}{4.5}$ M 3 $\frac{---}{6+}$. The subspecific name *progressor* applies to the prominence of the ectotrefoils on all four ridge-crests of $l.M_2$. In brief,

TYPE OF ANANCUS ARVERNENSIS PROGRESSOR KHOMENKO

Fig. 604. Type mandible of *Mastodon arvernensis* Croiz. et Job. var. *progressor* Khomenko, 1912, from southern Bessarabia, Russia. After Khomenko, 1912, Pl. I, fig. 1. Seven-fiftieths natural size.

Second and third inferior molars, $l.M_2$, $l.M_3$, five-twelfths natural size. After Khomenko, 1912, Pl. I, figs. 1, 2.

this molar is more complex than that of *Anancus arvernensis brevirostris* of Gervais (Fig. 597). The author's specific description is as follows:

Mastodon arvernensis Croiz. et Job. var. *progressor* Khomenko, 1912. Ann. Géol. et Minér. de la Russie, Vol. XIV, livr. 6, pp. 159–166. TYPE.—Lower jaw with M_2-M_3 *in situ*. HORIZON AND LOCALITY.—From near the village of Gavanosy, district of Ismaïl, southern Bessarabia, Russia. Probably Pliocene. TYPE FIGURE.—*Op. cit.*, 1912, Pl. I.

TYPE DESCRIPTION.—(Khomenko, *op. cit.*, p. 165): "La variété que je propose de nommer *Mastodon arvernensis* Croiz. et Job. var. *progressor*, s'est séparé du tronc principal comme une branche latérale au moment où l'espèce examinée avait des défenses à la mâchoire inférieure et où l'on n'observait encore aucune tendance de changement des molaires dans le sens pentalophodonte. Plus tard, la variété que je décris perdit complètement les défenses inférieures, mais les molaires, en rapport avec le genre de nourriture, restèrent tetralophodontes et commencèrent seulement à percer plus tôt. Le manque de la nourriture préférée et le manque d'assimilation aux nouvelles conditions vitales ont pu influer sur la disparition de cette variété qui n'a pas laissé de postérité."

In contrast to this type, Khomenko (p. 165) mentions an Italian type more conservative in structure, to which, he says, the application of the name *Mastodon arvernensis* Croiz. et Job. var. *conservativus* would be appropriate. This name has no technical standing.

Anancus sinensis Hopwood, 1935

For description and figure of Dr. A. Tindell Hopwood's new species *Pentalophodon* [*Anancus*] *sinensis* from Shansi, China, see Appendix to the present Volume I.

7. CRANIA OF THE BREVIROSTRINE MASTODONTS OF EURASIA

In the above figure (Fig. 591, p. 626) there are assembled outline reproductions after Falconer and Cautley, Weithofer, and Osborn, of the principal crania described up to 1920, namely:

'*Mastodon*' *sivalensis*, front views of two referred crania, after Falconer and Cautley, 1846 [1847, Pl. XLIII, fig. VIII, Pl. XXXII = *Pentalophodon falconeri*].

'*Mastodon*' *sivalensis*, crania and lower jaws, after Falconer and Cautley, 1846 [1847, pl. XLV, fig. VIII, Pl. XXXIII, fig. 1 = *P. falconeri;* Pl. XXXV, figs. 1, 1*a* = *P. sivalensis*].

'*Mastodon*' *sivalensis*, view of palate, after Falconer and Cautley, 1846 [1847, Pl. XXXIII, fig. 2 = *Pentalophodon falconeri*].

CRANIA OF ANANCUS

CHARACTERS OF THE CRANIUM.—The front, lateral, and palatal views of the cranium of '*Mastodon*' [= *Anancus*] *perimensis* (Figs. 605, 591) as compared with those of '*M.*' [= *Pentalophodon*] *sivalensis* and '*M.*' [= *Stegomastodon*] *mirificus* indicate the passage from a mastodontine into an elephantine type of cranium, through the decided abbreviation of the rostrum of the skull, of the anterior portion of the symphyseal region of the lower jaw, correlated with the loss of M^2-M_2. (1) The *Anancus* and *Pentalophodon* crania approach the true elephantine type, with extreme hypsicephaly and fore-and-aft abbreviation, so that the profile of the skull of

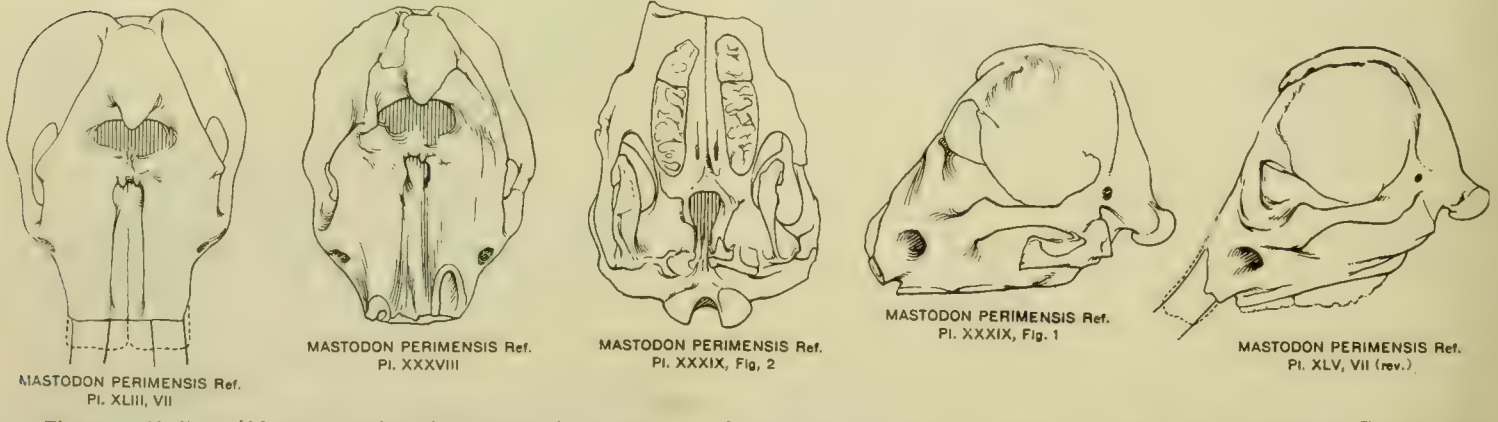


Fig. 605. Skulls of '*Mastodon*' *perimensis*, as figured by Falconer and Cautley from two referred specimens. Drawn after Falconer and Cautley, 1846 [1847, Pl. XLIII, VII, Pl. XXXVIII, Pl. XXXIX, figs. 2 and 1, and Pl. XLV, VII (rev.)]. These skulls are far more primitive and mastodontoid than the skull of '*M.*' *sivalensis* [= *Pentalophodon falconeri*]. Lydekker (1886.1, p. 57) erroneously selected as the *type* of '*M.*' *perimensis* the skull (Brit. Mus. M. 2882) figured in Pls. XXXVIII and XXXIX, as redrawn in this figure. Osborn selects this same cranium as a paratype of '*M.*' [*Anancus*] *perimensis* (see Fig. 612).

LECTOTYPE (OSBORN, 1933).—Falconer's first mention of the name "*M. perimensis*" is on Pl. XXXI, figs. 9, 9*a*, of the "Fauna Antiqua Sivalensis," Pt. IV, 1847, reproduced (Fig. 606) in the present Memoir; this third right superior molar (Brit. Mus. 14744) must be regarded as Falconer's type of '*Mastodon*' *perimensis*. PARATYPE (OSBORN, 1933).—The aged cranium (three central views) may be regarded as a *paratype* (see Fig. 612).

'*Mastodon*' [= *Anancus*] *arvernensis*, front and side views of crania, after Weithofer, 1890, Tav. IV, fig. 1, and p. 112.

'*Mastodon*' [= *Anancus*] *perimensis*, side view of cranium, after Falconer and Cautley, 1846 [1847, Pl. XLV, fig. VII].

To this comparison should be added the following:

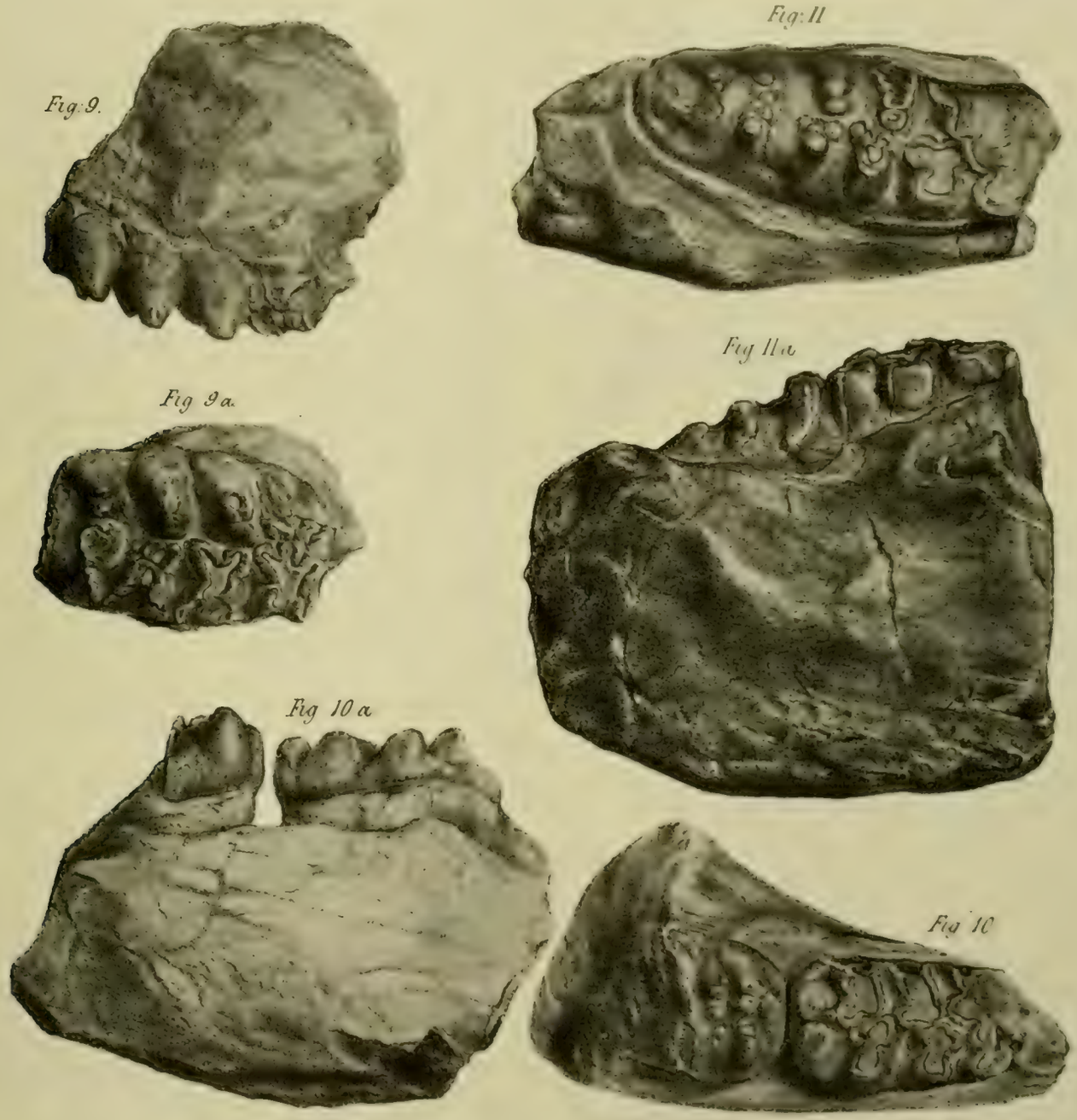
'*Mastodon*' [= *Anancus*] *perimensis*, two crania, after Falconer and Cautley, 1846 [1847, Pl. XXXVIII, Pl. XXXIX, figs. 1, 2; Pl. XLIII, fig. VII (Fig. 605 above)].

'*M.*' *sivalensis* [*Pentalophodon falconeri*] (Fig. 591) is as hypsicephalic as that of the mammoth (*Mammonteus primigenius*); it is much more abbreviate than that, for example, of the African elephant (*Loxodonta africana*). (2) This abbreviation accompanies the concentration of the entire power of mastication on the third superior and inferior molars, M^3-M_3, which assume a labyrinthine pattern.

SKULLS OF THE BREVIROSTRINÆ (W. D. MATTHEW, SEPTEMBER, 1920; BRITISH MUSEUM).—The original skull of '*Mastodon*'

sivalensis [=*Pentalophodon falconeri*] is of a smoky black color [Fig. 614]. The palate is extended forward and the roots of small tusks are present. The skull has excessively short elephantoid proportions; M^2 with only five(?) crests. The skull of '*Mastodon*' [=*Anancus*] *perimensis* is much less shortened up. This is a relatively small animal and appears to be quite primitive; the palate is not more depressed than in *Mastodon americanus;* two molars are broken off; the tusks are small.

Affinities to Trilophodon and Pentalophodon.—The crania of *Anancus perimensis*, as figured by Falconer and Cautley,



Type of Anancus perimensis, Figs, 9, 9a, Perim Island, Middle Pliocene; Referred, Figs. 10–11a

Fig. 606. *Mastodon perimensis* Falc. and Caut., 1846 [1847, Pl. xxxi, Figs. 9, 9*a*, 10, 11*a*], one-third natural size. The *type* specimen was first figured and mentioned by Falconer (Falconer and Cautley, 1846 [1847, Pl. xxxi, Figs. 9, 9*a*]—Brit. Mus. 14744) and was described as follows (Falconer, 1867, p. 44): "Figs. 9, 9*a*—*Mastodon Perimensis* (Falc. and Caut.).—From Perim Island. Portion of upper jaw, right side, with molar, presenting characters [alternation of cones] similar to those of *M. Sivalensis* and *M. Arvernensis*.—B. M. Length, 6.3 in. Width, 3.3 in."

Figs. 10, 10*a* (Brit. Mus. 14740), 11, 11*a* (Brit. Mus. M.2852) are two specimens *referred* by Falconer and Cautley and by Lydekker to this species. See Falconer's description of these two specimens, also Lydekker's definition of this species cited below.

remind us strongly of the Miocene bunomastodonts, such as certain species of *Trilophodon* and *Tetralophodon*, in the following characters:

(1) The relatively primitive elongation of the rostrum in front of the orbits, as contrasted with the extreme abbreviation of the cranium in *Pentalophodon falconeri*. (2) This elongate rostrum is an adaptation to the presence of two grinding teeth in use at the same time, namely, M 2-M 3, as contrasted with *Pentalophodon* in which only M 3 is in use at once in adults. (3) The occipital condyle is very prominent and pedunculate—a unique feature in the Proboscidea. (4) The frontal region of the cranium is relatively narrow or laterally compressed. (5) The summit of the cranium is also narrow, since the temporal fossæ are divided by a relatively narrow frontoparietal plate as compared with the very broad frontoparietal plate in *Pentalophodon falconeri* (Fig. 591). These cranial characters are beautifully displayed in figure 612 of this Memoir, which is a reproduction of Falconer's Pl. XXXIX, figs. 1, 2, 3. In his descriptive text, Falconer (1867, pp. 50, 51) gives the principal characters of this skull as follows: "The most remarkable character of all about this head is the low height of the pterygoid processes of the sphenoid, which are very little higher than the condyles, and the comparatively little elevation of the condyles above the palate. The interval between the plane of the lower surface of the condyles and that of the palate is only 5 inches, the height of the occiput being 22 inches. This is very much as in the North American Mastodon, and even more so, so that the plane of the grinder does not differ much from that of the condyles, . . . There are two large palatine foramina near the end of the molar. The molars (allowing perhaps for some distortion from pressure) run parallel, and do not at any rate diverge in the remarkable way exhibited by *M. Ohioticus;* perhaps they are less divergent even than in *M. Sivalensis.* The palate looks long. On either side are two molars, the penultimate and last true. The tusks exhibit an oval outline on section. Both zygomatic arches are entire. Presented by Captain Fulljames to B. M."

Osborn, 1924: The grinding teeth of *Anancus perimensis* (Fig. 606) relate this animal to the primitive bunomastodonts, e.g., *Phiomia* and *Trilophodon*, in the blocking of the valleys by the trefoil conules, as clearly shown in figure 606, 9*a*, 10, 11; they agree with the longirostral *Phiomia* and *Trilophodon* in the elongation of the third inferior molars. This demonstrates that *Anancus* springs from the bunomastodontine and not from the mastodontine stock. The crania also demonstrate this ancestry.

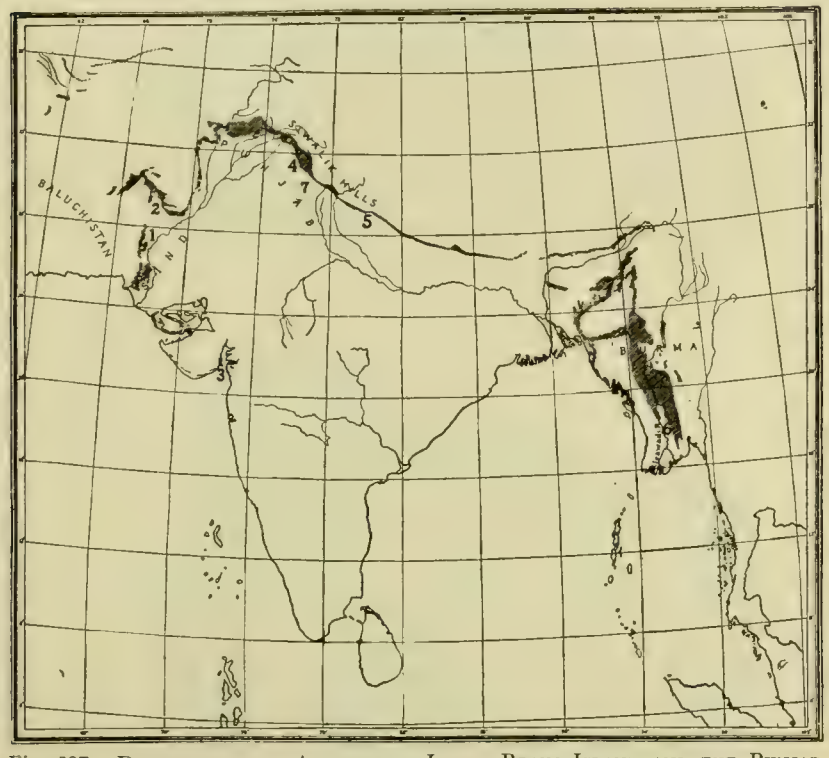


Fig. 607. Distribution of Anancus in India: Perim Island and the Punjab and Sub-Himalayan Siwaliks.

After Osborn, 1910.346, p. 325, fig. 155. Compare fuller and more accurate recent map (forming back end-paper of the present Volume I).

1. Manchhar beds; **2.** Bugti Hills; **3.** Perim Island; **4.** Punjab Siwaliks; **5.** Sub-Himalayan Siwaliks; **6.** Beds of the Lower Irrawaddy, after Oldham; **7.** Beds of the Salt Range, Lower Chinji, Mio-Pliocene.

Fig. 608. Middle and Upper Siwaliks of the Salt Range of the Punjab, India

See Figure 607, **4, 7** (Punjab Siwaliks)

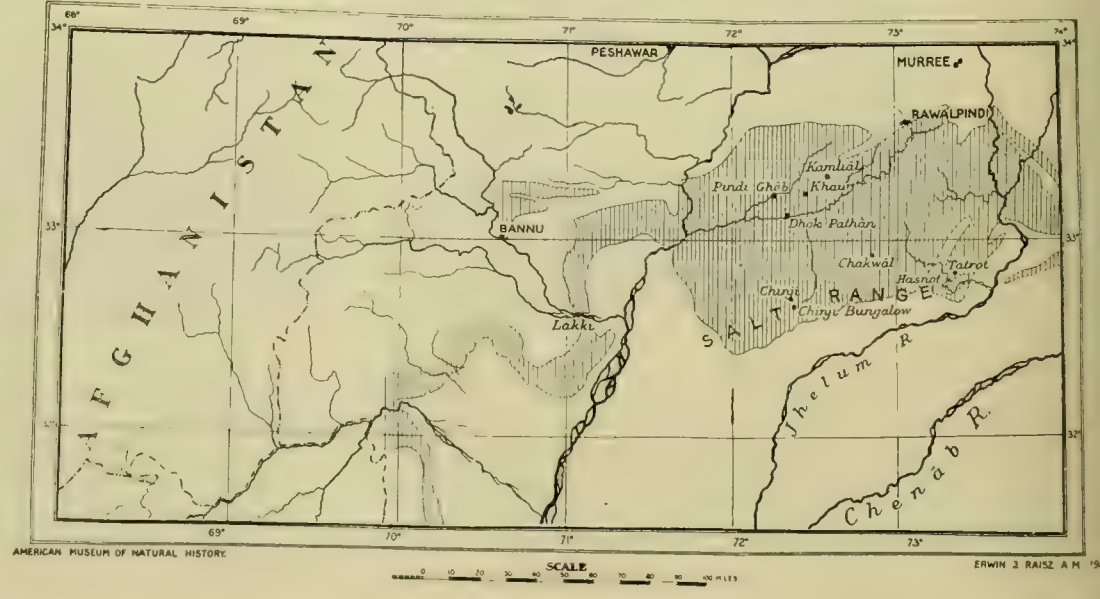
Upper Pliocene, Tatrot: *Pentalophodon sivalensis* [= *falconeri*] type.

Middle Pliocene, Dhok Pathan: *Synconolophus dhokpathanensis* type. *Stegodon bombifrons* type.

Mio-Pliocene, Upper Chinji. *Trilophodon macrognathus* type. *Deinotherium indicum* ref.

Mio-Pliocene, Lower Chinji: *Anancus properimensis* type. *Stegolophodon cautleyi progressus* type.

Middle Miocene, Kamlial: *Trilophodon palæindicus* type.



III. SUCCESSION OF THE BREVIROSTRINES IN INDIA

The known geographic distribution (Figs. 607, 608, see also maps of India) of the Brevirostrinæ is from Perim Island, northwest India (3) to the Punjab Siwaliks (4) and the Sub-Himalayan Siwaliks (5). There is no indication of this subfamily in the Lower Manchhar beds (1), or in the Bugti beds of Baluchistan (2), or in the Irrawaddy beds of Burma (6). First appearance in India is the *Anancus properimensis* sp. nov. of the Mio-Pliocene (7). In descending order the geologic succession (more clearly set forth with its accompanying fauna in Figs. 413, 414, Chap. X) is as follows:

Upper Siwaliks, Upper Pliocene, Pinjor? and Tatrot?
Pentalophodon sivalensis Cautley. Ridge-crest formula: M 2 $\frac{5}{5}$ M 3 $\frac{6\frac{1}{2}}{6\frac{1}{2}}$.
Pentalophodon falconeri sp. nov. Ridge-crest formula: M 3 $\frac{7\frac{1}{2}}{\ }$.

Middle Siwaliks, Middle Pliocene, Dhok Pathan Horizon, Hasnot, Salt Range.
Synconolophus corrugatus Pilgrim. Ridge-crest formula: M 3 $\frac{\ }{5\frac{1}{2}}$. Enamel highly plicated.

Middle Siwaliks, Middle Pliocene, Dhok Pathan Horizon, Dhok Pathan and Bhimbar.
Synconolophus dhokpathanensis Osborn. Ridge-crest formula: M 2 $\frac{3\frac{1}{2}}{\ }$ M 3 $\frac{\frac{1}{2}\ddagger}{5\frac{1}{2}}$.
Synconolophus propathanensis Osborn. Ridge-crest formula: M 2 $\frac{\ }{3\frac{1}{2}}$ M 3 $\frac{\ }{\frac{1}{2}-4-\frac{1}{2}}$.
Synconolophus hasnoti Pilgrim. Ridge-crest formula: M 3 $\frac{\ }{5\frac{1}{2}}$. Enamel smooth.

Middle Pliocene, Perim Island.
Anancus perimensis Falconer and Cautley. Ridge-crest formula: M 2 $\frac{4\frac{1}{2}}{4\frac{1}{2}}$ M 3 $\frac{5\frac{1}{2}}{6\frac{1}{2}}$. Vestigial lower incisors.

Lower Siwaliks, Mio-Pliocene, Lower Chinji Horizon, Chinji Bungalow.
Synconolophus ptychodus Osborn. Ridge-crest formula: M 3 $\frac{\ }{5\ddagger}$.
Anancus properimensis sp. nov. Ridge-crest formula: M 3 $\frac{\ }{5\frac{1}{2}-6\frac{1}{2}}$.

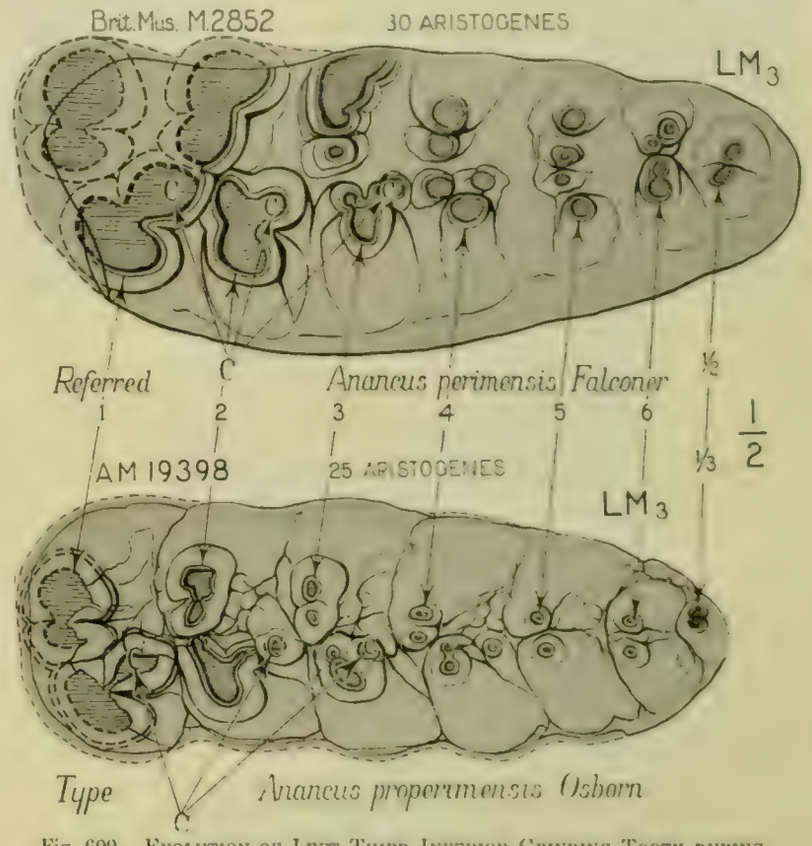


Fig. 609. Evolution of Left Third Inferior Grinding Tooth during Deposition of 7,500 feet of Sedimentation

(Upper) *Anancus perimensis* ref. Mio-Pliocene, Perim Island. Diagrammatic. After Falconer and Cautley (see Fig. 606, 11, 11*a*).

(Lower) *Anancus properimensis* sp. nov. Mio-Pliocene, Lower Chinji horizon. Diagrammatic. Amer. Mus. 19398. Compare figure 613 of the same specimen, also figure 581, page 613 (*A. perimensis*).

Anancus perimensis Falconer and Cautley, 1847

Figures 605, 606, 609–612, 617, 621

Middle Pliocene, Perim Island, India. Equivalent to Middle Pliocene, Plaisancien (of France) and Levantin (of Austria and Hungary).

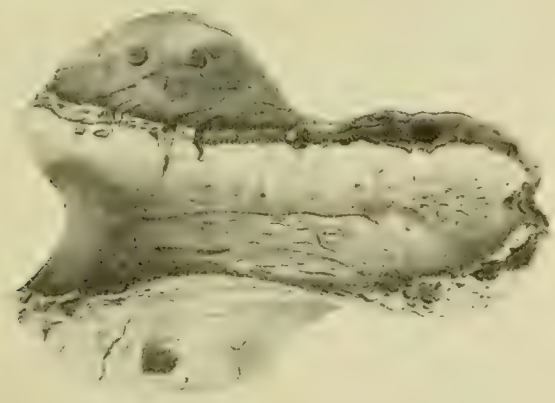
This is the second stage of *Anancus* thus far discovered; it was described by Falconer as *Mastodon perimensis*. As observed by Falconer (see legend of Fig. 606), the grinding teeth exhibit the *alternation* of the internal and external cones characteristic of all Brevirostrines. The ridge formula, namely, M 2 $\frac{4\frac{1}{2}}{4\frac{1}{2}}$ M 3 $\frac{5\frac{1}{2}}{6\frac{1}{2}}$, is higher than in *Anancus arvernensis;* the crowns are similarly brachyodont; the rudimentary trefoils are on the internal side of the superior molars and on the external side of the inferior molars. Consequently this Middle Pliocene south Asiatic species may be related to the Upper Pliocene *Anancus arvernensis* of Europe as well as to the *Pentalophodon sivalensis* of India. Otherwise it is far more primitive than the Upper Pliocene type of *Anancus arvernensis;* the grinding teeth are brachyodont and show affinities to the bunomastodonts; two grinders are in use at once. The type occurs in Perim Island, associated with remains of '*Mastodon*' [=*Stegolophodon*] *cautleyi* and *Hipparion punjabiense*.

It is extremely interesting to note that Falconer from the first observed a resemblance between the type molars of '*M.*' *perimensis*, '*M.*' *arvernensis*, and '*M.*' *sivalensis* in the progressive *alternation* of the internal and external cusps. Compare figure 613. We also observe on the three to four anterior ridge-crests (proto- to tetartolophids) *central conules* which unite to form *ectotrefoils* on the outer side of the inferior molars, as in *Anancus brevirostris* (Fig. 597). These *central conules* also appear in *Synconolophus hasnoti* molars (Fig. 627).

Mastodon perimensis Falconer and Cautley, "Fauna Antiqua Sivalensis," 1846 [1847, Pl. xxxi]. Type.—Falconer (in Murchison), 1867, p. 44: "Portion of upper jaw, right side, with molar." Lydekker (1886.2, p. 57) does not regard this

specimen (Pl. XXXI, figs. 9, 9*a*) as the type, but selects the "imperfect cranium" (Brit. Mus. M.2882), Falconer and Cautley, 1846 [1847, Pls. XXXVIII, XXXIX, our Fig. 612] as the type. HORIZON AND LOCALITY.—Middle Pliocene, Perim Island, India. TYPE FIGURE.—Falconer and Cautley, 1846 [1847, Pl. XXXI, figs. 9, 9*a*]. This specimen is Brit. Mus. 14744 and was the first that Falconer described and figured. Lydekker, however, 1886, p. 57, selected as the type the skull (Brit. Mus. M.2882) figured by Falconer and Cautley in Pls. XXXVIII and XXXIX, and fully described by Falconer (1867, pp. 50, 51). This skull undoubtedly belongs to the same species and may be regarded as Falconer's *paratype*.

TYPE DESCRIPTION.—Falconer (Murchison), 1867, p. 44, Pl. XXXI: "Figs. 9 and 9*a*.—*Mastodon Perimensis* (Falc. and Caut.). From Perim Island. Portion of upper jaw, right side, with molar, presenting characters similar to those of *M. Sivalensis* and *M. Arvernensis*.—B.M. Length, 6.3 in. Width, 3.3 in."



REFERRED SYMPHYSIS AND MOLAR OF ANANCUS PERIMENSIS. COMPARE SYNCONOLOPHUS PROPATHANENSIS (FIG. 633)

Fig. 610. Referred symphysis of '*Mastodon*' (*Tetralophodon*) *perimensis*. After Lydekker, 1880, Pl. XLIII, fig. 1, two-thirds natural size. Probably Dhok Pathan zone. Middle Pliocene.

(Lydekker, 1885, p. 99): Indian Museum "A.83. The symphysis of a mandible without tusks; from near Jabi, Punjab. Figured in the 'Pal. Ind.' ser. 10, vol. i., pl. xliii., fig. 1. *Collected by Mr. Theobald.*"

This referred trough-shaped symphysis is similar to that of *Synconolophus propathanensis* type (Fig. 633). No *associated* mandible of '*M.*' *perimensis* is mentioned or figured by Falconer.

REFERRED SPECIMENS

FALCONER, 1846.—Other specimens (Figs. 10, 10*a*, 11, 11*a*) referred by Falconer in Pl. XXXI, 1846 [1847], to *M. Perimensis*, 1867, p. 44, Pl. XXXI, are as follows: "Figs. 10 and 10*a*.—. . . Portion of lower jaw, left side, with penultimate and last true molars. Presented by Miss Pepper to B. M. Length of anterior molar, 4.8 in. Width, 2.6 in. Length of fragment of posterior molar, 2.1 in. Width, 2.8 in. Figs. 11 and 11*a*.—Fragment of lower jaw, with molar. Length of tooth, 8.4 in. Width, 3.5 in."

FALCONER, 1868.—Falconer's original observations on *M. perimensis* are confirmed in the "Palæontological Memoirs" of 1868, Vol. I, Pl. IX, figs. 3 and 4, in which is figured an M^1 of *M. perimensis* that strikingly suggests an ancestor of *M. sivalensis*.

In the description of this same plate, Falconer referred another specimen from Perim Island to *M. perimensis* which certainly resembles the *M. sivalensis* kind of molar. That Falconer regarded *M. perimensis* [Middle Pliocene] as related to *M. sivalensis* [Upper Pliocene] is further attested by the fact that he figured the skulls and teeth side by side, e.g., Falconer and Cautley, 1846 [1847, Pl. XXXIX], and Falconer, 1868, Vol. I, Pl. IX (in Murchison).

Lydekker refers to this species sixteen specimens (1886.2, pp. 57–59), from the Pliocene Siwaliks of Perim Island, Gulf of Cambay, India; of these eight belong either to *Anancus perimensis* or to *Stegolophodon cautleyi*.

LYDEKKER, 1880.—Lydekker (1880, Pl. XLIII) figures (Fig. 1) the symphysis of an abbreviated mandible (Ind. Mus. A.83) also (Fig. 2) the symphysis of a mandible broken anteriorly, showing in cross-section two small tusks (Ind. Mus. A.59); both specimens referred.

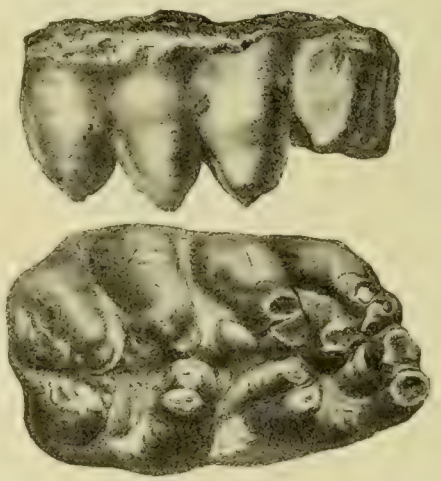


Fig. 611. Referred M^1 of '*Mastodon*' *perimensis*. After Falconer, 1868, I, Pl. IX, figs. 3, 4, one-half natural size: "Figs. 3 and 4. Show in plan and profile the antepenultimate molar of the upper jaw, left side, of *Mastodon Perimensis*, one-half of the natural size. The specimen was obtained from Perim Island, and is in the Museum of the Asiatic Society of Bengal."

Observe four conelets and *central conules*.

Lydekker (*op. cit.*, p. 239) remarks that Falconer on pages 12 to 15 of the second volume of the "Palæontological Memoirs" of 1868 classed *M. perimensis* "among the *Tetralophodons*, which have the columns of the transverse ridges arranged alternately, and the intervening valleys blocked; . . . the molars of this species have a considerable quantity of cement in the valleys." Lydekker recalls the discovery in the Punjab of a jaw of this species with partly abbreviated symphysis and remarks that "the species was provided with upper premolars, . . . the male was provided with small cylindrical mandibular incisors."

LYDEKKER, 1884.3.—Lydekker observed (1884.3, p. 153): "It has been shown in the first volume of the present work [1880] that *M. perimensis* is a species provided with a comparatively short mandibular symphysis with small tusks (pl. XLIII.), . . . it is quite evident that evolution has tended to the shortening of the mandibular symphysis and the suppression of the mandibular tusks; and it is

PARATYPE (OSBORN, 1933) SKULL OF ANANCUS PERIMENSIS. ONE-EIGHTH NATURAL SIZE

Fig. 612. Paratype skull of '*Mastodon*' *perimensis* Falconer and Cautley, from Perim Island. After Falconer and Cautley, 1846 [1847, Pl. XXXIX, figs. 1, 2, 3]. One-eighth natural size. Observe wide contrast to the progressive *Pentalophodon falconeri* cranium (Figs. 591 and 614).

This may be regarded as a *paratype* of '*Mastodon*' *perimensis*. It affords the characters of the skull but not of the teeth, the specific characters of which rest upon the specimen first described and figured by Falconer and Cautley, reproduced in figure 606 of this Memoir. Lydekker, however, in his Catalogue of 1886, p. 57, erroneously designates this skull (Brit. Mus. M.2882) as the type. See same aged cranium in three views (top, palate, and side), figure 605

therefore also pretty evident that the tetralophodont *M. perimensis* is a more specialized form than the trilophodont *M. pandionis*, which is considered to be an offshoot from the stock of *M. angustidens*. . . . Taking all these circumstances together, it is by no means improbable that *M. perimensis* may be a specialized descendant from the stock of *M. pandionis*." (See Fig. 610 above.)

FALCONER'S SPECIFIC DEFINITION OF 1868 OF MASTODON [=ANANCUS] PERIMENSIS

"Palæontological Memoirs," Vol. I, 1868, pp. 464, 470, Pls. XXXI and XXXVIII of the "Fauna Antiqua Sivalensis"

(1) *Mastodon perimensis* Falconer and Cautley, 1846 [1847, Pl. XXXI, figs. 9, 9*a*]. TYPE.—From Perim Island. (Falconer, 1868, p. 464): "Portion of upper jaw, right side, with molar, presenting characters similar to those of *M. Sivalensis* and *M. Arvernensis* (see *antea*, pp. 117, 122).—B. M. Length, 6.3 in. Width 3.3 in." M^2, ridges 4½, M^3, ridges 5½. (2) SKULLS.—Plate XXXVIII, skull, Perim Island, with M^2, M^3, length of M^{2-3} 11.7 in. = 296 mm. (3) According to the above notes, Falconer's type and referred ridge formula of *Mastodon perimensis* is as follows:

Mastodon perimensis: M 2 $\frac{4\frac{1}{2}}{-}$ M 3 $\frac{5-5\frac{1}{2}}{6\frac{1}{2}}$.

Osborn, 1924: For the ridge count of M 3, Lydekker gives $\frac{5\frac{1}{2}}{5\frac{1}{2}}$; if, however, we carefully examine the crown view of the referred figure (Fig. 606, 11, 11*a*), we observe that the count may be M 3 $\frac{-}{6\frac{1}{2}}$, because the sixth ridge exhibits four conelets, and behind this is a broad talon with two conelets, indicating an incipient half-ridge. It is this backward extension of the crown which suggests that *Anancus perimensis* may be ancestral to *Pentalophodon sivalensis*, in which the M 3 typically exhibits six and a half ridges.

LYDEKKER'S SPECIFIC DEFINITION OF 1886 OF MASTODON [=ANANCUS] PERIMENSIS

"Catalogue of the Fossil Mammalia in the British Museum (Natural History)," Part IV, 1886, pp. 56–59

Lydekker (1886.2, p. 56) gives the following definition of this species: "The cheek-teeth of this species are narrow, and contain a considerable amount of cement in their valleys;

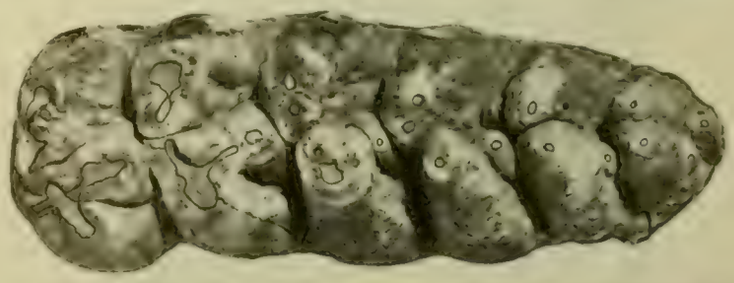
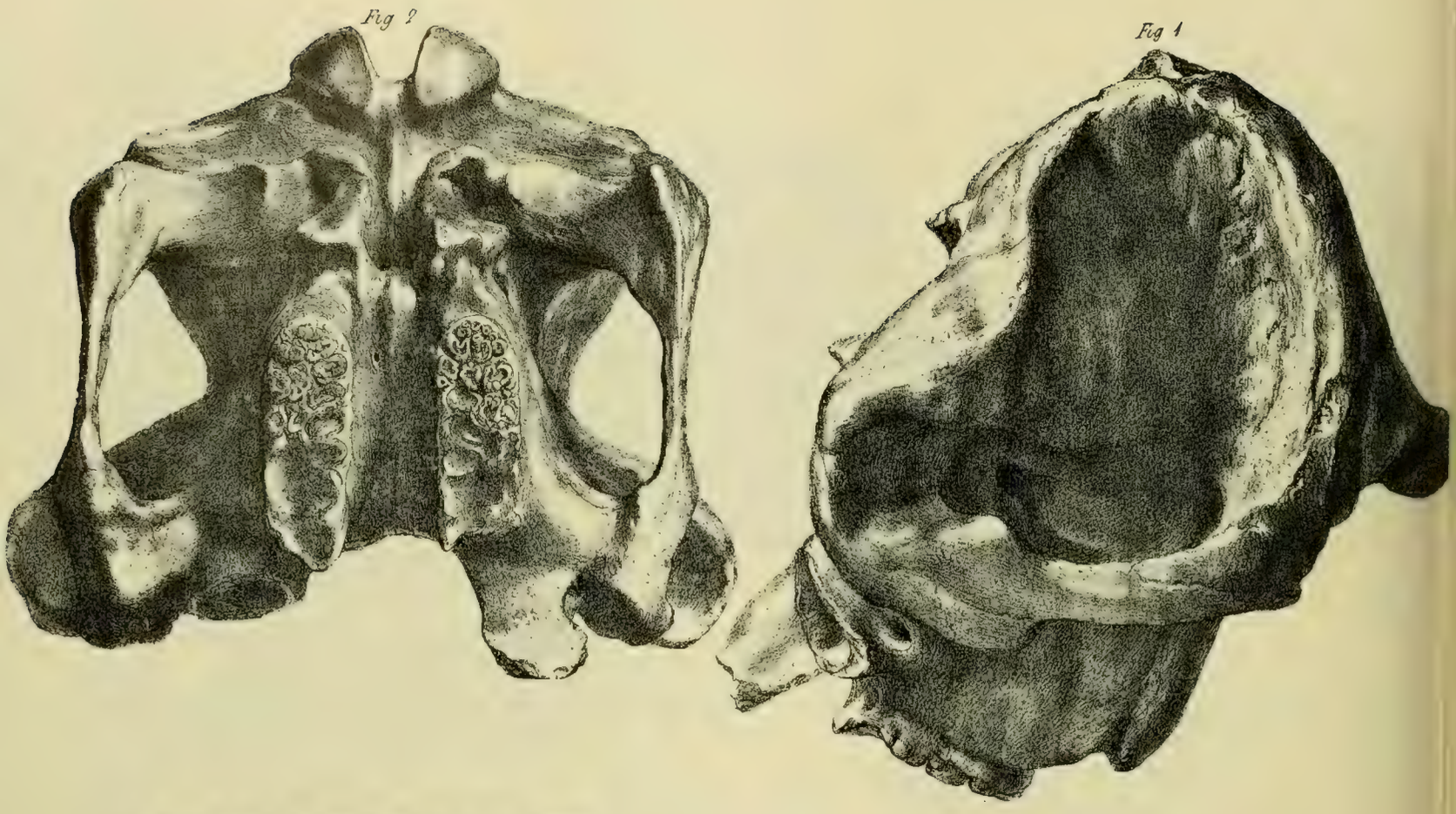
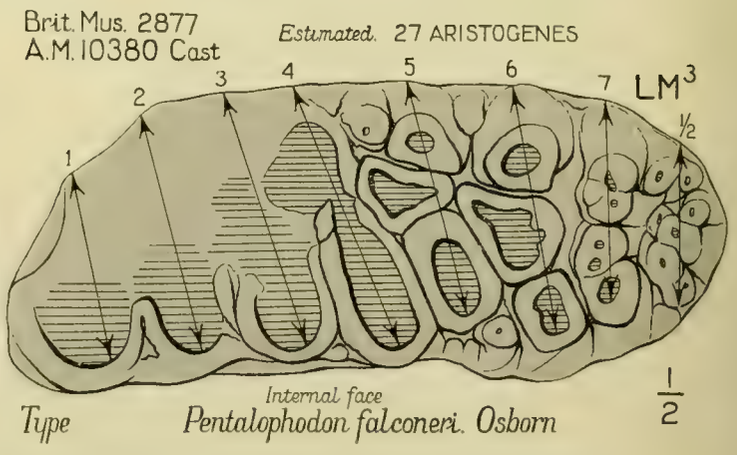


Fig. 613. *Anancus properimensis* sp. nov. (Amer. Mus. 19398), from 800 feet above base of Lower Siwaliks, 1 mile west of Chinji Bungalow, India. A third left inferior molar, l.M_3, with 6½ ridge-crests, measuring, ap. 196 mm., tr. 68 mm., height of metalophid 65e mm. Reduced to one-half natural size. Observe prominent *central conules* on three anterior crests, also warped or alternating external cones in trito-, tetarto-, and pentalophids. Compare with figure 597 of *Anancus arvernensis brevirostris*, a right third lower molar; also with *Synconolophus* lower molars (Fig. 632). Observe also that the type level of *Anancus perimensis* is Middle Pliocene, whereas the present form is reported from the Lower Chinji horizon, Mio-Pliocene.

NOTE (Osborn, 1933): The biconed fifth and sixth ridge-crests (penta- and hexalophids), each consisting of two prominent cones, also the rudimentary seventh ridge-crest (heptalophid), are narrower and more primitive than in the *A. perimensis* type (Fig. 606); accordingly this primitive Mio-Pliocene stage is named *Anancus properimensis* (see Fig. 609).





TYPE OF PENTALOPHODON FALCONERI SP. NOV. CRANIUM (BRIT. MUS. M.2877) REFERRED TO 'MASTODON' SIVALENSIS BY FALCONER, 1868
ONE-SIXTH NATURAL SIZE

Falconer's referred cranium probably comes from the Upper Siwaliks, 1,000 feet above the Middle Pliocene Dhok Pathan of the Siwaliks

Fig. 614. Referred skull of *'Mastodon' sivalensis*. After Falconer and Cautley, 1846 [1847, Pl. XXXIII: fig. 1, left lateral view; fig. 2, palate]. (Lydekker, 1886.2, p. 47) Brit. Mus. M.2877: "The imperfect cranium of a female, showing the half-worn $^{m.3}$ of either side. Figured by Falconer and Cautley, *op. cit.* pls. xxxii. and xxxiii. figs. 1 3; the former figure is copied in 'Falconer's Palæontological Memoirs,' vol. i. pl. x. The molar appears to have six ridges. *Cautley Collection. Presented*, 1842." Cast Amer. Mus. 10380. See enlarged molars (one-third natural size—lower left); diagram (one half natural size — lower right).

Falconer [in Murchison] writes in the "Palæontological Memoirs," 1868, Vol. I, p. 129, regarding this same skull: "A fine specimen of *Mastodon Sivalensis* is represented in Pl. x., which is copied from Pl. xxxii. of the Fauna Antiqua Sivalensis." The student will find the full description of this skull on pages 464, 465 of the same volume.

The clear specific distinctions between Cautley's type (Fig. 616) of *'Mastodon'* [=*Pentalophodon*] *sivalensis* and Osborn's type (Fig. 614) of *P. falconeri* sp. nov. are given below.

their columns, which are arranged somewhat alternately, are tall and comparatively thin antero-posteriorly; a trefoil is formed on one column of each ridge, and the valleys are almost completely blocked by accessory tubercles. There is a large hind talon to the upper 'intermediate' molars, and the third upper true molar is moderately tapering posteriorly, its hind talon consisting of large cusps. The mandibular symphysis is unknown [Footnote: 'The specimens figured in the 'Palæontologia Indica,' ser. 10, vol. i. pls. xl.–xlii. (except pl. xli. fig. 4), are now referred to a distinct species (*M. punjabiensis*, *q.v.*).'], and the milk-molars have not yet been determined; it is uncertain whether premolars were developed."

Anancus properimensis sp. nov.

Figures 609, 613, and 621

Mio-Pliocene. One mile west of Chinji Bungalow, India, Lower Chinji horizon, 800 feet above the base of the Lower Siwaliks.

The discovery by Barnum Brown of the type of *Anancus properimensis* in the Mio-Pliocene of the Lower Chinji horizon, 7,500 feet below *Anancus perimensis* of the Middle Pliocene, reveals the mode of evolution of the species of the genus *Anancus*, as follows: (1) The evolution in size and proportion (alloiometric); (2) the addition of five new conelets (aristogenes), also (3) the broadening of the transverse ridge-crests, especially in 4–5–6 (the tetarto-, penta-, hexalophids) and rudimentary biconed heptalophid (⅛, ½).

Type.—Third left inferior molar, l.M_3 (Amer. Mus. 19398). Type Figure.—Figures 609 and 613 of the present Memoir.

Specific Characters.—Ridge-crests, cones, trefoils, central conules, and conelets much more primitive in structure than in *Anancus perimensis*, especially the tetarto- to heptalophids which exhibit simple double cones. A total of twenty-five separate conical points or aristogenes as compared with thirty conical points or aristogenes in the corresponding molar of *A. perimensis* (cf. Fig. 606, 11, 11*a*, also type figure 613, and diagram 609). Ridge-crests 5–6–7 narrow, with two cones each, instead of the broad ridge-crests, with four cones each, in *A. perimensis*.

1. CHARACTERS OF THE GENUS PENTALOPHODON FALCONER 1857, 1865

Genus: **PENTALOPHODON** Falconer, 1857, 1865

Genotypic species: *Mastodon sivalensis* Cautley, 1836.

Original reference: Quart. Journ. Geol. Soc. London, Vol. XIII, p. 314 (Falconer, 1857.1).

The name *Pentalophodon* first appears in 1857 (Falconer, 1857, p. 314): "For reasons which will be explained in the sequel, it would seem that there has existed in nature another subgeneric group of *Mastodon*, of which only a single form is at present known, in which the crowns of the 'intermediate molars' are divided upon a quinary ridge-formula. This group in our arrangement would be characterized, in harmony with the others, as *Pentalophodon:* and it may with some confidence be predicated, that, when the dentition shall have been well determined, the second milk-molar will present four ridges, and the last true molar six ridges in the upper jaw."

Generic Description (Falconer, 1857, 1865).—In the above description Falconer had in mind *Mastodon sivalensis*, which in 1865 he clearly designated as the genotypic species of *Pentalophodon* (Falconer, 1865, p. 262): "It appears to me that the Indian fossil species *M.* (*Tetralophodon*) *Sivalensis*, figured in the 'Fauna Antiqua' [Footnote, '*Op. cit.*, pl. 36, figs. 1–6.'], presents the first indication in that direction. In the 'intermediate molars' of this form, both upper and lower, besides the usual anterior 'talon' and four large ridges, there is a fifth ridge, somewhat reduced in size, but exactly corresponding with the other in form, composed of several large mammillary tubercles, separated from the next ridge by a valley, and throwing off an outlying tubercle, which reduces the valley, as in *M.* (*Tetralophodon*) *Arvernensis*, to lateral gorges. This fifth ridge is not a mere offset from, or subordinate appendage to, the fourth ridge after the ordinary manner of a 'talon.' It is supported directly by the last fang, and is separated, both on the outer and inner sides, from the latter by the intervening valley. . . . In a fine specimen of a penultimate upper molar of *Mastodon Sivalensis*, which is now before me, the fifth ridge, although well developed and attaining the height of the fourth, bears no trace of a 'talon' appended to it;

while an antepenultimate lower, which I have also before me, shows distinctly five ridges the last differing in no respect of complexity or development from the others, except in being a little smaller, and it bears a distinct crenulated adpressed 'talon' appendage, having the appearance of a terminal 'bourrelet.' . . . The ridge-formula for the true molars in *Mastodon Sivalensis*, is inferred to be $\frac{5+5+6}{5+5+6\text{-}7}$; and when the dentition is fully made out, it is anticipated that the complete ridge-formula will be nearly thus:—

Milk-molars.	True molars.
$\frac{2+4+5}{2+4+5}$.	$\frac{5+5+6}{5+5+6\text{-}7}$."

Falconer's descriptions and definitions of '*Mastodon*' *sivalensis* are chiefly based on specimens figured in three of his superb plates, namely: (1) Plate XXXVI, figs. 4, 4*a*, 5, 5*a*, superior and inferior molars; (2) Plate XXXVII, figs. 7, 8, 8*a*. (3) These molars agree closely in size and character with Cautley's type (Fig. 616) and they display Falconer's ridge formula: M 2 $\frac{5}{5}$ M 3 $\frac{6}{6\text{-}7}$. (4) This agreement with Cautley's type (Figs. 616, 615) renders probable Falconer's molar ridge formula.

Altogether different and much more progressive are the grinding teeth of the cranium (Pl. XXXIII, fig. 2) reproduced herewith in figure 614, which Osborn makes the type of the new species *Pentalophodon falconeri*.

Genotypic and Specific Error (Osborn, 1933).—(1) Falconer and subsequent writers and commentators up to the present time, namely, Lydekker, Pilgrim, Osborn, erred in overlooking the primitive specific characters of Cautley's type figure (Fig. 616) of '*Mastodon*' *sivalensis*. Cautley's type third inferior molar (Fig. 616) with 6½ ridge-crests is far more primitive than the referred superior molar, l.M^3, with 7½ ridge-crests in Falconer's *referred* cranium (Fig. 614) of '*M.*' *sivalensis*. Falconer partly based his generic and specific definition of *Pentalophodon sivalensis* on this *referred* cranium and dentition (Fig. 614) rather than on Cautley's primitive *type* specimen (Fig. 616) and the isolated molars (Figs. 615, 618) which Falconer rightly referred to '*M.*' *sivalensis*.

(2) A very close comparison and analysis of the molars, shown (Fig. 614) to a one-third scale, proves that Falconer's *referred* cranium (Fig. 614) belongs to a much more progressive species, if not genus, than Cautley's type molar of '*Mastodon*' *sivalensis* (Fig. 616). Osborn, retaining Cautley's type (Fig. 616) of '*M.*' *sivalensis* as the genotypic species, now makes this referred cranium (Brit. Mus. M. 2877) the type of a new species in honor of Hugh Falconer, namely, *Pentalophodon falconeri*, as a progressive species of *Pentalophodon*.

(3) *Geologic Age of Pent. sivalensis.*—After most careful examination of articles by Cautley and by Falconer, of the years 1832–1836, Barnum Brown concludes that Captain Cautley was certainly working on the Doab Canal, between the Jumna and the Ganges, southeast of Simla, and collecting in the vicinity of Nahun, now classified as Upper Siwaliks, equivalent to the Upper Pliocene.

(Journ. Asiatic Society of Bengal, Vol. V, December, 1836, p. 770) The Editor, Dr. James Prinsep, received a letter from Captain Cautley announcing "the discovery of a superb specimen of the *Mastodon angustidens*, a skull with both lines of molars, palate, and one orbit entire. . . . A very perfect head of a horse [*Equus sivalensis*] has also just been extracted by the *Sewalik* working parties, from the hard sandstone."

Thus founded on two Upper Siwalik (Pliocene) species, the more primitive true *Pentalophodon sivalensis* Cautley, also the more progressive species *Pentalophodon falconeri* sp. nov., the genus *Pentalophodon* may be redefined as follows:

Generic Characters (Falconer, 1857, 1865, Osborn, 1933).—(1) Second superior and inferior molars with 5 ridge-crests. (2) Third superior and inferior molars with ridge-crests progressive from 6½ (*Pentalophodon sivalensis* Caut.) to 7½ (*P. falconeri* sp. nov.). (3) Superior and inferior ridge-crests alternating and extending obliquely backwards from the external to the internal faces, typically composed of three main irregular cones, set widely apart in *P. sivalensis* Caut. (6½ ridge-crests in 220 mm.); closely compacted in *P. falconeri* sp. nov. (7½ ridge-crests in 200 mm.). (4) Crown progressively chœrodont with twenty-two aristogenes in M_3 of *P. sivalensis* Caut., twenty-seven in M^3 of *P. falconeri* sp. nov. (5) Ridge-crests (*Pentalophodon*) distinguished from *Synconolophus* and *Anancus* by three main transverse cones as compared with four transverse cones (*Synconolophus* and *Anancus*), also enamel smooth not ptychoid (*Pentalophodon*), irregularly folded or ptychoid (*Synconolophus*). (6) No trefoils, distinguished also from *Anancus* by absence of ecto- and entotrefoils, and by presence of *central conules* in two anterior valleys. (7) Cranium of *Pentalophodon* lofty, hypsicephalic, brachyopic, as compared with *Synconolophus*, platycephalic, dolichopic, brachyeranial. (8) Distinguished from *Anancus perimensis* by elevated occipital condyles.

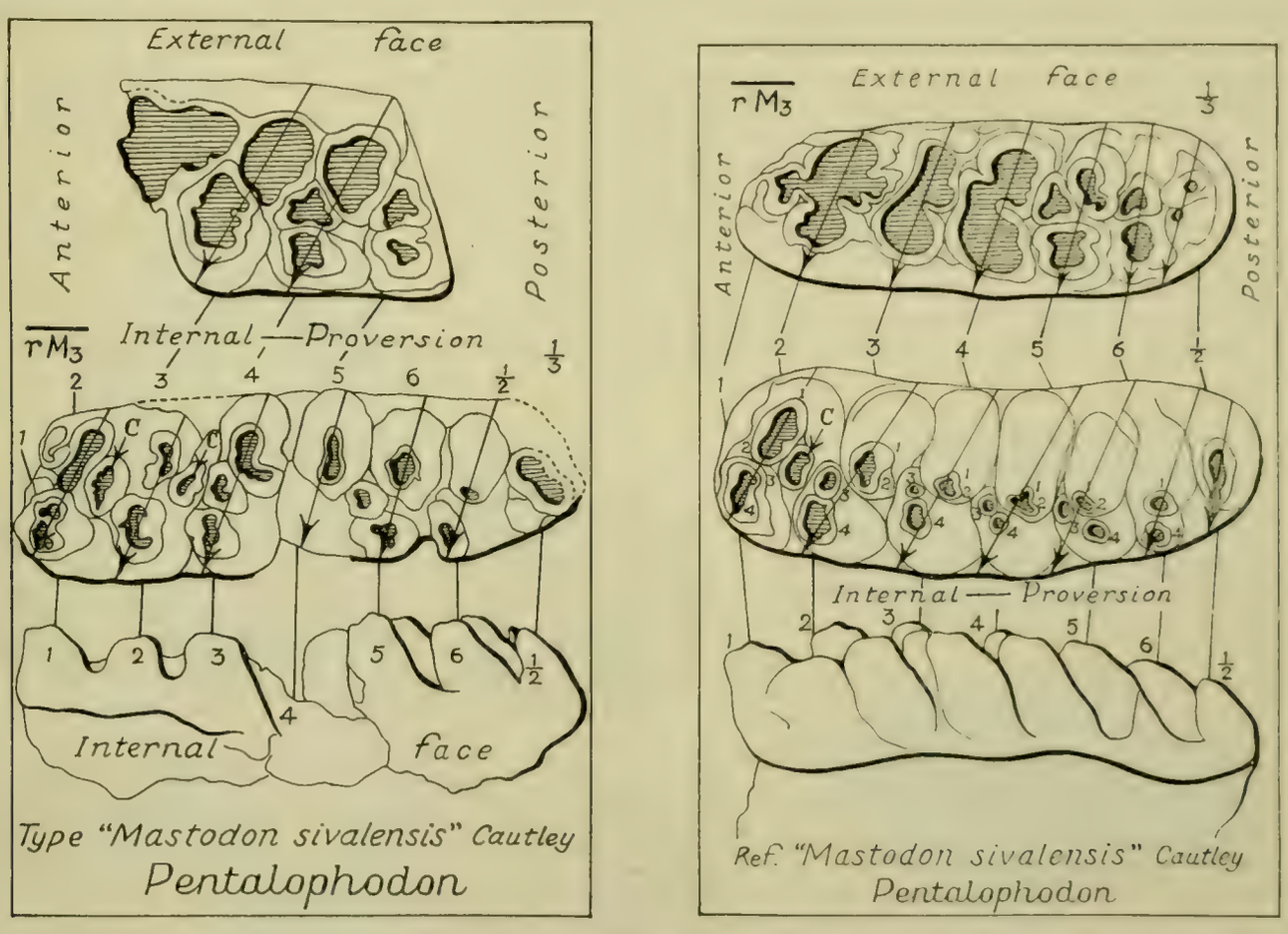


Fig. 615. Pentalophodon sivalensis Cautley, 1836. Strong internal proversion of 6½ inferior ridge-crests. Cones synconodont or compacted

One-third natural size

(Left) *Pentalophodon sivalensis* type: Diagrammatic restoration of Cautley's fractured type (cf. Fig. 616) exhibiting strong *proversion of* 6½ ridge-crests each consisting of four closely compacted conelets; the external pair of conelets tends to become conercscent on wear; in the two anterior valleys are seen (C——C) small central conules; each ridge-crest is strongly *proverted* internally; this type molar is relatively brachyodont, the ridge-crests 1-6 being relatively low; altogether 22 separate conelets and conules equaling 22 estimated aristogenes.

(Right) *Pentalophodon sivalensis* ref. (Fig. 7, upper) and ideotype, Brit. Mus.M.2874 (Fig. 8, 8*a*, lower). Crowns reversed. After Falconer and Cautley, 1846 [1847, Pl. xxxvii, figs. 7, 8, 8*a*.] More progressive; ridge-crests more elevated; strong internal *proversion*; conelets and central conules (C——C) strongly compacted, synconodont; 22 estimated aristogenes, as in type.

2. THE UPPER PLIOCENE PENTALOPHODON SIVALENSIS CAUTLEY, DENTITION

Pentalophodon sivalensis Cautley, 1836

Figures 615, 616, 618, 621

Doab Canal,[1] between the Jumna and Ganges, southeast of Simla, vicinity of Nahun, now classified as Upper Siwaliks, equivalent to the Upper Pliocene.

The type of *Mastodon sivalensis* Cautley, 1836 (Fig. 616) is a 6½ crested molar. (Hopwood, letter, Feb. 10, 1932): "*Pentalophodon sivalensis* Cautley. Apparently the *holotype* of this species is lost, or at least mislaid. I suppose that it may have been among the specimens presented to this Museum by Cautley in 1842 or 1846, but this does not appear likely since the specimen is never referred to again either by Falconer or Lydekker. My own impression is that the specimen was lost soon after Cautley wrote his note on it, anyway we have most of the specimens which he figures but not this one, the most important of them all."

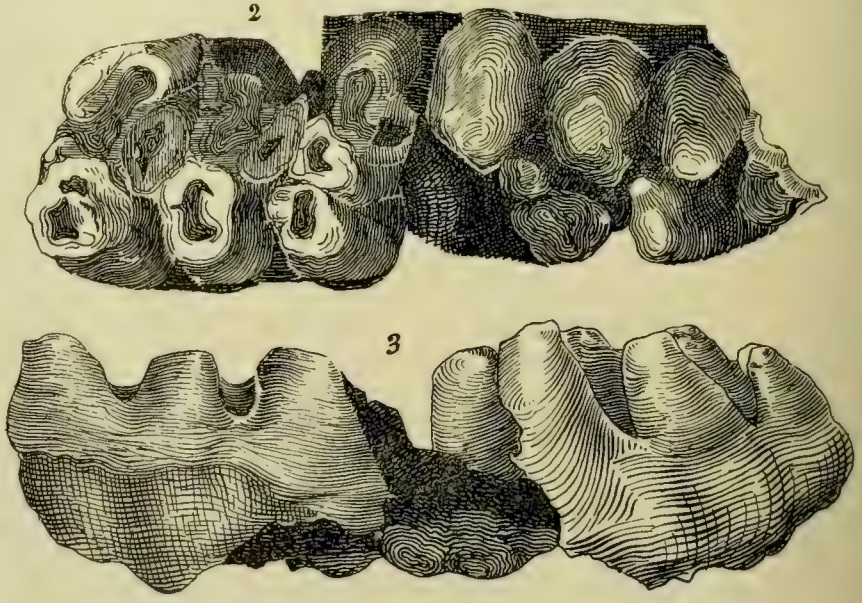
Dr. Proby T. Cautley, in his quaint original description of *Mastodon sivalensis* (1836, p. 295), pointed out the alternating arrangement of the main cones of the grinding teeth as closely similar to those of *Mastodon arvernensis* of Asti, Upper Pliocene of Italy. He should thus be credited with discovering its phyletic position, a discovery confirmed and amplified by Falconer, who in 1865 made this highly progressive species, with five-ridged intermediate molars, the genotype of *Pentalophodon*, a subgenus of *Mastodon*; M 3 $\frac{6}{6\text{-}7}$.

M. [*Mastodon*] *Sivalensis* Cautley, 1836. "Note on the Teeth of the Mastodon à dents étroites of the Siwâlik Hills." Journ. Asiatic Soc. Bengal, Vol. V, p. 294. TYPE.—(*Op. cit.*, p. 295): . . . "perfect molar of a young but adult animal. . . . This is the right molar of the lower jaw." HORIZON AND LOCALITY.—Siwalik Hills, India. TYPE FIGURE.—*Op. cit.*, Pl. XI, figs. 2 and 3.

TYPE DESCRIPTION.—(Cautley, 1836, pp. 294–296). After referring the reader to Cuvier's figure of *Mastodon arvernensis* found at Asti, upper Italy, Cautley continues: "By comparing the accompanying drawings with the figures above alluded to, there can be no demur, I imagine, in identifying the Siwâlik variety of Mastodon now under review with the Asti fossil. It remains therefore simply to note the peculiarities in form of the tooth: although it may be a point of consideration hereafter, whether, as the character of the tooth is so marked, and its peculiarities so rigidly adhered to throughout the whole of the remains found in the Siwâliks, it may not be placed under a subgenus, that of '*angustidens*,' with the specific denomination of *M. Sivalensis*. . . . The coronal surface consists of a double line of conical and obtusely pointed mamillæ: those on the external side being in most cases perfect, whilst those on the inner side are divided by a fissure or fissures into two or three irregularly formed obtuse points. These mamillæ are not, as in the true Mastodon angustidens, placed transversely or at right angles with the line of surface, but meet each other from right to left alternately, so that the furrow on one side is interrupted by the mamilla on the other; and the mamillæ on the whole line of tooth lock into each other in the same way that two serrated edges opposed to each other might be supposed to do, were they placed in contact. The outer surface of the enamel is smooth, and the space or furrow between each mamilla both on the external and internal surface is marked by a small tubercle, the presence of which however does not appear to be constant." There follows a minute description of the tooth, after which Cautley concludes (p. 295): "I wish to draw attention particularly to the alternating position of the mamillæ, which I consider to be the chief specific character, and which is distinctly marked throughout the whole series; and, referring again to the Asti fossil as figured in Cuvier, I think that a clear identification is established."

He then observed (p. 296): "Up to this period I am only aware of the discovery of two species of mastodons in the Siwâlik hills; namely, the *variety* of *M. angustidens* which is the subject of this note, and the *M. Elephantoides* of Clift. The former is very rare, and the latter in very great abundance."

OSBORN'S IDEOTYPE OF 'MASTODON' SIVALENSIS CAUTLEY (FIGS. 615, 618).—Osborn (1933) selects as an *ideotype* a 6½ ridge-crested right lower molar, r.M_3, Brit. Mus. M.2874 (Falc. and Caut., 1846 [1847, Pl. XXXVII, figs. 8, 8*a*]), a perfect molar (Figs. 615, 618) which is in close agreement in size and form with Cautley's *type* (Fig. 616). Both Cautley's type and Osborn's ideotype molars agree very closely in size, in proportions, in number of ridge-crests, in brachyodont height of the ridge-crests, in number of conical points or *aristogenes*, a summary of these specific characters being as follows:



TYPE OF PENTALOPHODON SIVALENSIS CAUTLEY, 1836

Fig. 616. Type of *Mastodon Sivalensis* Cautley, 1836, Pl. XI, figs. 2 and 3, one-half natural size. "Perfect molar of a young but adult animal . . . This is the right molar of the lower jaw. The length of this tooth is 9.2 inches or .234 metres, and the breadth . . . 2.95 inches or .074 metres." The original specimen [type] has been lost or mislaid (cf. Fig. 615).

[1]See map of the Punjab (constituting the back end-paper of the present Volume), prepared by Erwin J. Raisz in 1927, which has been modified to include the Doab Canal and the village of Nahun, as shown in Pl. III of the "Palæontological Memoirs" of 1868, Vol. I.

Pentalophodon sivalensis Cautley	Cautley's Type R.M_3 (Cf. Fig. 616)	Osborn's Ideotype R.M_3 Brit. Mus. M.2874
Ridge-crests	6½	6½
Length	9.2 in. or 234 mm.	8.8 in. or 225 mm.
Breadth	2.95 or 74	2.9 or 74
Index	32	33
'Aristogenes,' single or paired cones and conelets	22	22
Estimated height of 5th ridge-crest	80	72

Observations of Falconer and Lydekker on Pentalophodon

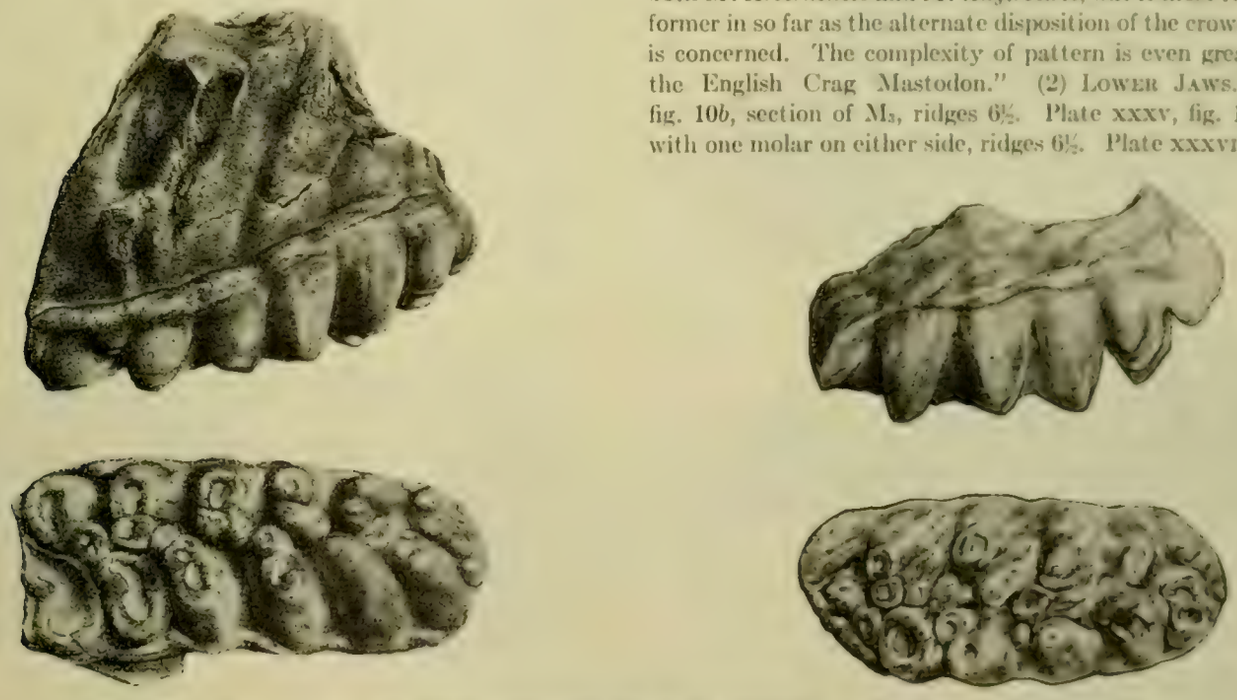
As clearly set forth above, these observations relate to specimens in the British Museum and in the Calcutta collections, which are now distinguished as belonging either to the more primitive *Pentalophodon sivalensis* Cautley (probably of the Pinjor horizon) or to the more progressive *P. falconeri* Osborn (of the Tatrot? horizon).

Lydekker (1880, p. 249).—Lydekker observes: "It thus appears that in his last notice, Dr. Falconer considered *M. sivalensis* to have a complete pentalophodont ridge-formula. . . . [Falconer, 1865, p. 263] 'and when the dentition is fully made out, it is anticipated that the complete ridge-formula will be nearly thus—Milk-molars $\frac{2+4+5}{2+4+4}$. True molars $\frac{5+5+6}{5+5+(6-7)}$.'"

Falconer's Observations and Measurements of Mastodon [=Pentalophodon] Sivalensis

"Palæontological Memoirs," Vol. I, 1868, pp. 425, 465–497, description of Pls. III, XXXII–XXXVI of the "Fauna Antiqua Sivalensis"

Pentalophodon sivalensis Cautley, 1836, Pl. XI, figs. 2, 3. Type, r.M_3, with 6½ ridges. (1) Upper Jaws. Plate III, fig. 10*a*, section of M^3, ridges ½–5–½. "There are five principal ridges, with a subordinate ridge in front, and a talon ridge behind." Length of molar 7 in. = 178 mm. Plate XXXIV, fig. 1, skull with palate, M^{2-3}, M^2 with 4½ ridges, that is, 4 ridges and a heel, length 4.7 in. = 120 mm., width 2.8 in. = 73 mm.; M^3 with 5 ridges; diagonal connection between inner and outer discs as in *Mastodon arvernensis*, points or denticles in *sivalensis* very high, obtuse; length of M^3 6.4 in. = 164 mm.; width 3 in. = 76 mm.; figs. 2, 2*a*, upper jaw, M^3, with 6 ridges. Plate XXXVI, figs. 4, 4*a*, upper jaw with M^2, ridges 5, alternately disposed crown mammillæ; figs. 5, 5*a*, upper jaw, with ?M^3, ridges 5½, length 6.5 in. = 166 mm., width 2.9 in. = 75 mm.; figs. 6, 6*a*,[1] upper jaw, M^3, ridges 6½. "It has six ridges and a hind talon, and in this respect it differs from both *M. Arvernensis* and *M. longirostris*, but it most resembles the former in so far as the alternate disposition of the crown mammillæ is concerned. The complexity of pattern is even greater than in the English Crag Mastodon." (2) Lower Jaws.—Plate III, fig. 10*b*, section of M_3, ridges 6½. Plate XXXV, fig. 1, lower jaw with one molar on either side, ridges 6½. Plate XXXVII, figs. 1, 1*a*,



Referred L.M^3 of Anancus perimensis (Left) compared with Referred L.M^3 of Anancus falconeri (Right)

Fig. 617. Referred '*Mastodon*' *sivalensis* [=*Anancus perimensis*] (left) and referred '*Mastodon*' [=*Anancus*] *arvernensis* [=*falconeri*] (right). After Falconer and Cautley, 1846 [1847, Pl. XXXVI, figs. 6, 6*a*, 9, 9*a*', one-third natural size.

Left figures: *Anancus perimensis* (6, 6*a*), from the Siwalik Hills, India: "Last molar, upper jaw, left side in plan and profile. It has six ridges and a hind talon, and in this respect it differs from both *M. Arvernensis* and *M. longirostris*, but it most resembles the former in so far as the alternate disposition of the crown mammillæ is concerned. The complexity of pattern is even greater than in the English Crag Mastodon.—Cast in B. M. . . Length of tooth, 7.8 in. Width, 3.3 in." (Falconer, 1868, I, p. 467). Brit. Mus. M.2857.

Right figures: *M.* [=*Anancus*] *arvernensis* [=*falconeri*] (9, 9*a*), dredged from the sea between Southwold and Easton, Suffolk, England: "Another specimen of last true molar, upper jaw, left side. This is Captain Alexander's specimen dredged up between Southwold and Easton, and of which there is a cast in the Museum of the Geological Society. The specimen is very black with a sandy matrix and no vertical pillaring. The crown consists of five ridges and a heel ridge of four points." (Falconer, *op. cit.*, p. 468.) Cast Brit. Mus. M.2903.

[1]Referred by Osborn to *Anancus perimensis* (see Fig. 617 of present Memoir).

portion of lower jaw, right side, with Dp_2, Dp_3, length of Dp_2, .6 in. = 15 mm., breadth .4 in. = 10 mm., length of Dp_3, 1.8 in. = 46 mm., width 1.1 in. = 27 mm.; figs. 2, 2*a*, portion of lower jaw, left side, two outer mentary for., Dp_2 and Dp_3, length of Dp_2 .4 in. = 10 mm., width .4 in. = 10 mm., length of Dp_3 1.9 in. = 49 mm., width 1.2 in. = 30 mm., height at anterior margin 2.3 in. = 59 mm.; figs. 3, 3*a*, portion of lower jaw, right side, with symphysis and Dp_4, fragment of M_1, length of Dp_4 3.5 in. = 89 mm., width 2 in. = 51 mm., height at posterior margin 4.2 in. = 107 mm.; figs. 8, 8*a*, fragment of lower jaw, left side, perfect specimen of M_3. The alternate disposition of the mammillæ of the crown is finely exhibited. Length of M_3 8.8 in. = 225 mm., width 2.9 in. = 74 mm.[1] (3) Skulls.—Plate xxxii. Skull with M^3, ridges 7½, length 7.8 in. = 200 mm., width 3.3 in. = 84 mm. Plate xxxiii, figs. 1, 2, 3, lateral, palatal, and occipital views of same skull as that figured in Pl. xxxii [= *P. falconeri* sp. nov.].

According to the above notes (Falconer, 1868), the formula of the referred specimens of *Pentalophodon sivalensis* is as follows:

Ideotype (Osborn) of Pentalophodon sivalensis Cautley

Fig. 618. A six and a half ridged right lower molar of '*Mastodon*' *sivalensis*. After Falconer and Cautley, 1846 [1847, Pl. xxxvii, figs. 8, 8*a*], one-third natural size. Brit. Mus. M.2874, transferred from the Old Indian Museum, 1880.

(Lydekker, 1885, p. 93): "A.120 [Ind. Mus.]. Cast of a fragment of right ramus of the mandible containing the third true molar. The original is from the Siwalik Hills, and is figured (reversed) in the 'F. A. S.' pl. xxxvii., fig. 8. It is in an early condition of wear, and shows six ridges and a talon; the alternate arrangement of the column is very well marked."

This ideotype of *Pentalophodon sivalensis* Caut. agrees very closely with Cautley's type, as shown in the diagrammatic figure 615.

Falconer's type and referred ridge formula of *P. sivalensis*: M 2 $\frac{4\frac{1}{2}\text{-}5}{}$ M 3 $\frac{5\text{-}5\frac{1}{2}\text{-}\frac{1}{2}\text{-}5\text{-}\frac{1}{2}\text{-}6\text{-}6\frac{1}{2}}{5\text{-}5\frac{1}{2}\text{-}6\frac{1}{2}}$

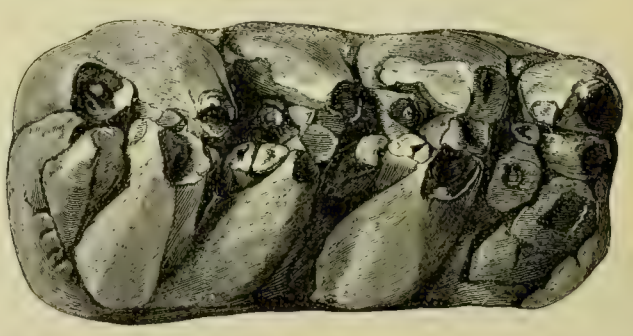
Lydekker's Notes of 1886 (Lydekker, "Catalogue of the Fossil Mammalia in the British Museum (Natural History)," Part IV, 1886, p. 47).—Lydekker (1886, p. 47) wrongly placed *Mastodon sivalensis* in the tetralophodont group, defining the species as follows:

"The cranium (woodcut, fig. 11 [Fig. 619 = *Pent. falconeri*]) of this specialized species is much vaulted, and the mandibular symphysis short and devoid of incisors. The inner and outer columns of the cheek-teeth are placed alternately (although there is some variation in this respect), and when worn present irregularly-shaped disks of dentine. In consequence of this arrangement the

Referred Pentalophodon falconeri

Fig. 619. Profile of skull of referred '*Mastodon*' *sivalensis*. Reproduced from Gaudry (1878, p. 185, fig. 245); one-sixteenth natural size. This is the same as woodcut figure 11 of Lydekker (1886.2, p. 48), Brit. Mus. M.2876, which Lydekker states is the same skull as that figured by Falconer and Cautley in the "Fauna Antiqua Sivalensis," Pl. xxxiii, fig. 4.

Fig. 12.



Mastodon sivalensis.—The first right lower true molar; from the Pliocene of the Siwalik Hills. ⅔. The lower border of the figure is the outer border of the specimen.

Referred Molar of Pentalophodon sivalensis or of P. falconeri

Fig. 620. Referred tooth of '*Mastodon*' *sivalensis*, regarded by Lydekker as an M_1. After Lydekker (1886.2, p. 51, fig. 12). Brit. Mus. 47888a.

Observe that this tooth is not fully pentalophodont. It may be regarded as four and a half crested. Lydekker may therefore be right in regarding it as a first lower molar, M_1, because the second lower molars in this species typically exhibit five complete crests.

[1]Ideotype (Osborn) of *Pentalophodon sivalensis* (see Figs. 615 and 618 of present Memoir).

valleys are completely blocked, and a small amount of cement is present. In some examples of the 'intermediate molars' there are five ridges [*Pentalophodon* stage], while there may be six in the last true molar; the enamel of the milk-molars is vertically grooved but in the true molars it may be either grooved or smooth; and premolars have not been observed. The cheek-teeth are very like those of *M. arvernensis;* but the number of accessory tubercles is frequently more numerous, and trefoils are never formed on the columns, while the number of ridges is sometimes greater. The two species are, however, closely allied."

To this collective species '*Mastodon*' [= *Pentalophodon*] *sivalensis* Lydekker referred twenty-four specimens in the British Museum (see pp. 47–52) from the *Cautley Collection* (1842), many of which were figured by Falconer and Cautley; also four specimens presented by Hugh and C. Falconer in 1867. The geologic reference is: India (Siwalik Hills and Punjab), Pliocene of the Siwalik Hills.

Phylogenetic Relationships (Osborn, 1924, 1933).—Comparison of the type (Fig. 616) as well as of all the referred specimens of *Pentalophodon sivalensis* with the type specimens of the Middle Pliocene *Synconolophus hasnoti* and *S. corrugatus* demonstrates that *P. sivalensis* belongs to the phylum with smooth, simple cones, not closely compressed at their summits as in *S. hasnoti*, nor corrugated as in *S. corrugatus;* also with relatively small conules; consequently the type of *P. sivalensis* shares the simple characters of the type of *Anancus arvernensis* and of the more primitive species *Anancus perimensis;* it certainly does not belong to the *Synconolophus* phylum.

Pentalophodon falconeri sp. nov.

Figures 614, 619, 621

Upper Pliocene, Tatrot? horizon. Probably from the Upper Siwaliks, 1,000 feet above the Middle Pliocene Dhok Pathan, India.

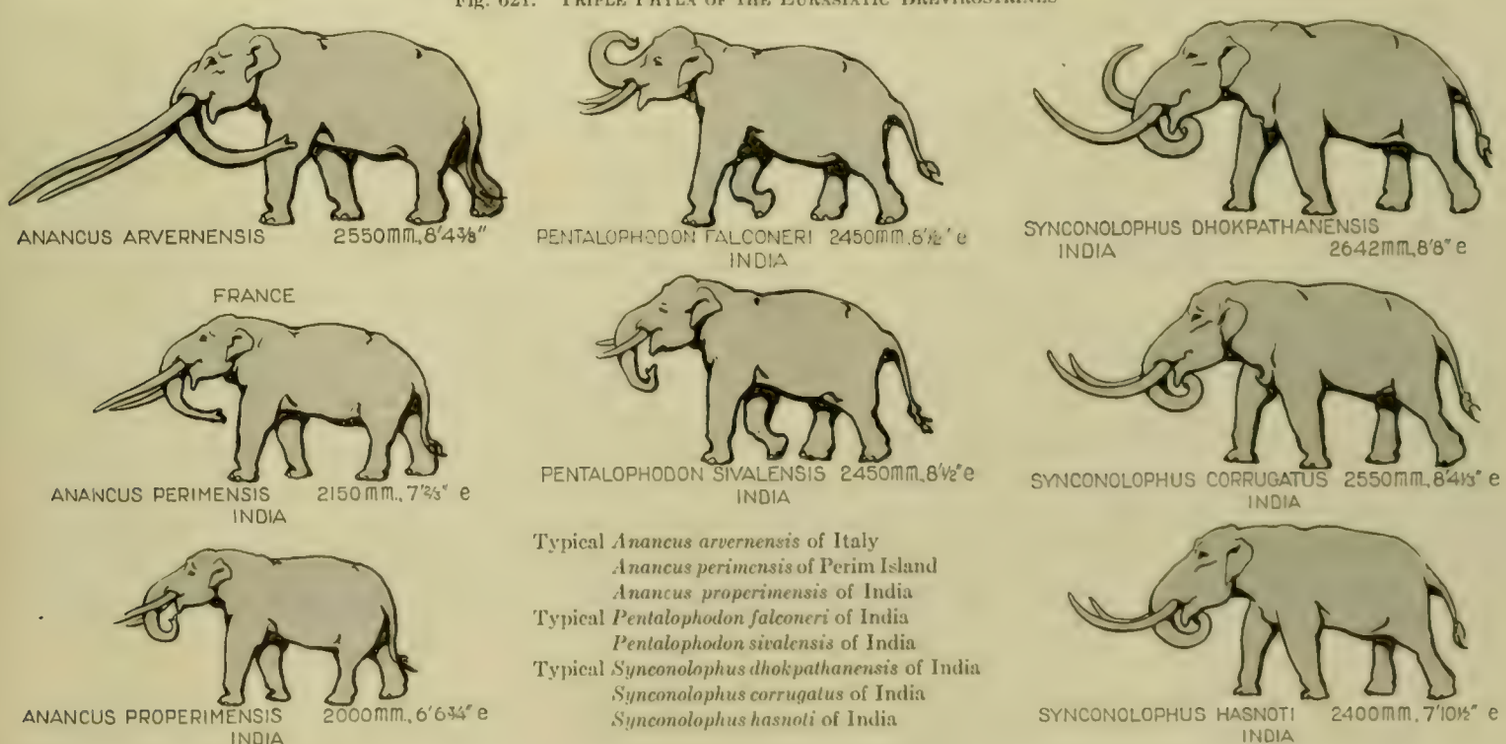
In Osborn's opinion, Brit. Mus. M.2877 (probably also M.2876), referred by Falconer and Cautley to '*Mastodon*' *sivalensis*, is in no way related to that species, nor to *Synconolophus* in which the cranium is of entirely different form, but represents a new species of *Pentalophodon*, to which the name *Pentalophodon falconeri* is applied in honor of Hugh Falconer.

Type.—Portion of cranium with superior grinding teeth (Brit. Mus. M.2877). Horizon and Locality.—(Falconer, 1867.1, p. 44): "From the Sewalik Hills." Probably from the Upper Siwaliks, Upper Pliocene, Tatrot? horizon, 1,000 feet above the Middle Pliocene Dhok Pathan, of the Middle Siwaliks, India. Type Figure.—Falconer and Cautley, 1846 [1847, Pls. xxxii and xxxiii, figs. 1 and 2]—compare figure 614 of the present Memoir.

Pentalophodon falconeri, sp. nov.	Brit. Mus. M.2877
Tatrot?, Upper Pliocene	R.M^3
Ridge-crests	5 plus "complicated heel series" Falc. [=7½]
Length	7.8 in. or 200 mm.
Breadth	3.3 or 84
Index	42
'Aristogenes'	27 est.

Specific Characters.—Osborn observes that the grinding teeth, M^3, in this cranium are highly chœrodont, that the intermediate conelets are very large and ptychoid or folded, and that the relatively broad proportions of the teeth differ from the narrow proportions of the relatively low-crowned type molar of '*Mastodon*' [*Pentalophodon*] *sivalensis* (Fig. 616). As shown in Falconer's figures of the third superior grinders enlarged and in the diagram of the type (Fig. 614), the grinders consist of 7½ ridge-crests composed of closely compacted cones and conelets, in which the middle conelets appear to be the largest, while in the type of *P. sivalensis* (Fig. 615, left) the middle conelets are relatively small. In the type of *P. falconeri* the estimated aristogenes are twenty-seven, whereas in the type and referred *P. sivalensis* there are only twenty-two aristogenes. In every way *P. falconeri* is very much more progressive than *P. sivalensis* and represents a much more advanced stage of evolution.

Fig. 621. Triple Phyla of the Eurasiatic Brevirostrines



3. THE MIOCENE AND MIDDLE PLIOCENE SYNCONOLOPHUS; CHARACTERS OF THE GENUS AND OF FOUR SPECIES

Genus: **SYNCONOLOPHUS** Osborn, 1929

Generic reference: Amer. Mus. Novitates, No. 393, December 24, 1929, pp. 9, 10 (Osborn, 1929.797).

Genotypic species: *Synconolophus dhokpathanensis* Osborn from the Dhok Pathan horizon, Middle Siwaliks, India. See also *Synconolophus propathanensis* from the Dhok Pathan and *S. ptychodus* from the Lower Chinji horizon, Lower Siwaliks, India.

Compare figures of *Mastodon* (*Trilophodon*) *pandionis* ref., Lydekker, 1880, Pl. xxxv, fig. 4 = the type of '*Tetrabelodon*' *corrugatus* Pilgrim, 1913; also *Mastodon* (*Tetralophodon*) *sivalensis* ref., Lydekker, 1880, Pl. xliv, fig. 3 = the type of '*Mastodon*' *hasnoti* Pilgrim, 1913. The specimens shown in these figures appear to be referable to *Synconolophus*.

Generic Characters.—Skull somewhat more elongate than in *Anancus*, *Pentalophodon*, or *Stegomastodon*. Basicranium elongate, also palate. Postnarial opening far back of grinders (*Synconolophus dhokpathanensis*). Tusks large, upturned, without enamel. Intermediate molars, Dp 4–M 2, with trilophodont ridge formula and small rudimentary half ridge-crests, representing pro-protoloph and tetartoloph. Grinders with ridge-crests strongly arched or dislocated. Valleys blocked with warped, compacted conelets and conules, giving on wear a strongly chœrodont, ptychoid, crowded, compressed, enamel-bordered appearance, as implied in the generic name *Synconolophus;* no trefoils. Ridge formula: Dp 4 $\frac{\frac{1}{2}-3}{=}$ M 1 $\frac{\frac{1}{4}-3-\frac{1}{2}}{=}$ M 2 $\frac{\frac{1}{2}-3-\frac{1}{2}}{=}$ M 3 $\frac{\frac{1}{2}-4-\frac{1}{2}}{\frac{1}{2}-5-\frac{1}{2}}$. Mandibular rostrum broad, trough shaped, concave superiorly (*S. propathanensis*, Fig. 633); tusks reduced or absent; large, fleshy lower lip.

History.—We do not recognize in Falconer's plates (1845–1847) or descriptions grinding teeth referable to this peculiar genus *Synconolophus*; all the specimens he figures and describes appear to be referable to either *Anancus* or *Pentalophodon*. But in Lydekker's Memoir of 1880, "Siwalik and Narbada Proboscidia," we observe numerous examples of grinding teeth referable to *Synconolophus*, namely:

Plate XXXIV, *Mastodon* (*Trilophodon*) *pandionis* Falc., figs. 1, 2, second and third right lower true molars, r.$M_{2\text{-}3}$..... = *Synconolophus* (?) sp.

Plate XXXV, *Mastodon* (*Trilophodon*) *pandionis* Falc., figs. 1–3; also fig. 4, third right lower true molar = type of '*Tetrabelodon*' *corrugatus* Pilgrim, 1913..... = *Synconolophus corrugatus*.

Plate XXXV A, *Mastodon* (*Trilophodon*) *pandionis* Falc., second and third left upper true molars, l.$M^{2\text{-}3}$ = *Synconolophus* (?) sp.

Plate XXXVI, fig. 1, elongated symphysis, said to have been found with the type r.M_3 of '*Tetrabelodon*' *corrugatus* Pilgrim, 1913 (see Lydekker, *op. cit.*, Pl. xxxv, fig. 4). Possibly erroneous association.

Plate XLI, *Mastodon* (*Tetralophodon*) *sivalensis* and *M.* (*T.*) *perimensis* F. & C., figs. 2, 4 = *Synconolophus* (?) sp.

Plate XLIV, *Mastodon* (*Tetralophodon*) *sivalensis* F. & C., fig. 2, an r.Dp_3; fig. 3, third right lower true molar, r.M_3, from a nearly complete jaw = type of '*Mastodon*' *hasnoti* Pilgrim, 1913. = *Synconolophus hasnoti*.

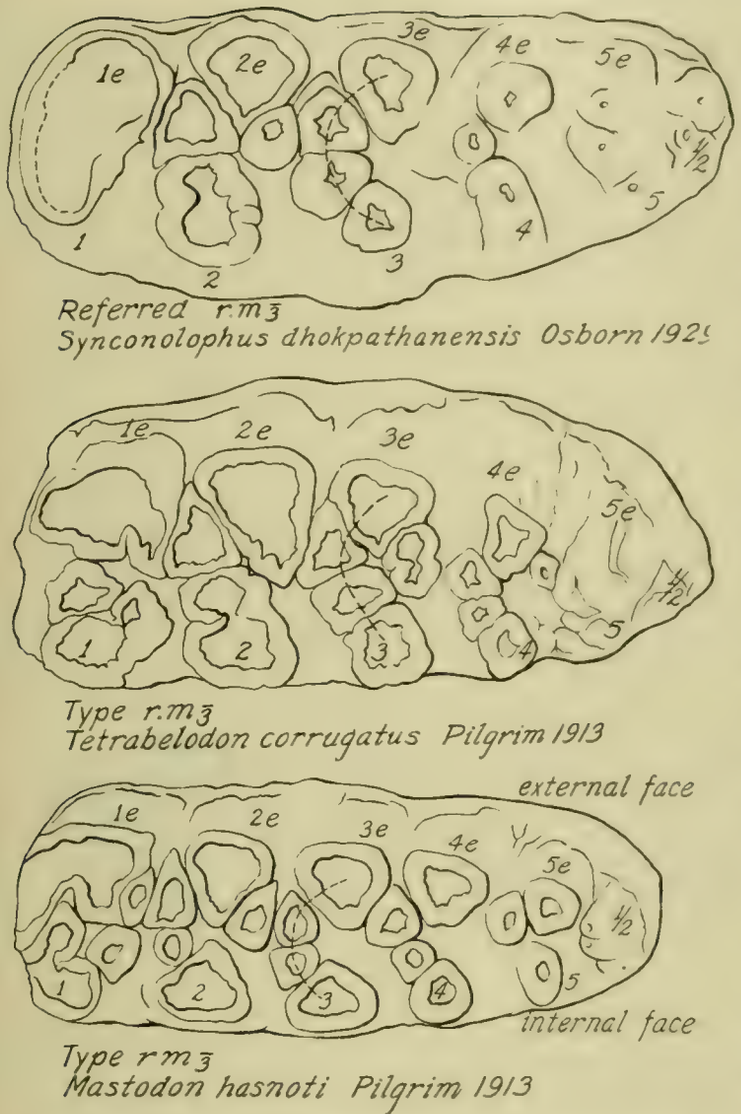


Fig. 622. Comparison of third right inferior type and referred molars of *Synconolophus*, about one-half natural size. Observe *alternation* and *dislocation*. Compare fig. 581, p. 613.

(Upper) Referred right third inferior molar, r.M_3, of *Synconolophus dhokpathanensis* (compare Fig. 632). Amer. Mus. 19485c.

(Middle) Type right third inferior molar, r.M_3, of *'Tetrabelodon' corrugatus* Pilgrim, 1913, after Lydekker, 1880, Pl. XXXV, fig. 4 (compare Fig. 626).

(Lower) Type right third inferior molar, r.M_3, of *'Mastodon' hasnoti* Pilgrim, 1913, after Lydekker, 1880, Pl. XLIV, fig. 3 (compare Fig. 627).

Observe (1) protolophid, (2) metalophid, (3) tritolophid, (4) tetartolophid, (5) pentalophid, and (½) hexalophid rudiment; also lateral compression of ridge-crests and alternation of internal and external cones, internal cones (1–5) warped anteriorly, external cones (1e–5e) warped posteriorly; the lateral compression of the cones of each transverse ridge-crest (3–3e) is forwardly arched, the middle cones being crowded anteriorly (dotted lines). There can be no doubt as to the generic relationship of these three forms, but we cannot determine positively the specific relationship until the original specimens, or casts, are placed side by side. See also irregular median conules or trefoils.

Specific Revision. — According to the above review of Lydekker's determinations he erroneously referred all these complex, ptychoid grinding teeth of *Synconolophus* to species treated in this Memoir as *Pentalophodon sivalensis*, *Anancus perimensis*, and *Trilophodon pandionis*, the latter a species from the Larkana District of Sind, originally described by Falconer, to which subsequently Lydekker erroneously referred many teeth now found to be referable to *Synconolophus* ?sp. The type specimen of *'Mastodon'* [=*Trilophodon*] *pandionis* was compared by Lydekker (1886.2, pp. 37, 38) with the milk dentition of *Mastodon pentelicus* (compare this Memoir, pp. 261 to 266).

Pilgrim rightly removed two of these specimens, renaming them *'Tetrabelodon' corrugatus* and *'Mastodon' hasnoti*. With the aid of Barnum Brown's discovery of a cranium (Fig. 630), Osborn rightly groups all these species under the genus *Synconolophus;* their close affinity is revealed in the structure of the third inferior molar teeth, as shown in the accompanying figure 622.

Discovery of the Synconolophus Cranium

The discovery by Barnum Brown in 1922 of a skull (Figs. 629, 630) of the hitherto unrecognized *Synconolophus*, a generic phylum extending from the Lower Chinji into the Dhok Pathan horizon, is one of the most interesting and important additions which this great explorer has made to the history of palæontology. The present author first examined the giant Dhok Pathan cranium (Amer. Mus. 19673—Figs. 629, 630) and was much puzzled especially by the curious structure of the superior molar teeth (Fig. 630 A1), broad, short, with the internal cones displaced and apparently only *four* ridge-crests. The three-ridged second molar, M^2, suggested comparison with *Trilophodon*, but the broad four-ridged third molar, M^3, differed from that of *Trilophodon* and also from that of *Tetralophodon punjabiensis* (Fig. 324) which occurs in the same geologic horizon. It was not until perfect superior molars of *Synconolophus* were found, such as the paratype third right superior molar (Amer. Mus. 19720—Fig. 631) and from the same horizon a pair of referred superior and inferior molars (Amer. Mus. 19485*a–d*—Fig. 632) that the structural and phyletic key to this very aberrant genus could be determined.

It becomes clear that the warping or dislocation of the cones and crests in the superior and inferior molars is much more extreme than in *Anancus* (Fig. 596) or in *Stegomastodon* (Fig. 643), also that the multiplication of separate intermediate conelets, originally springing from the trefoils, is quite distinct from the regular single or double trefoils of *Stegomastodon*. In the paratype superior molar of *Synconolophus dhokpathanensis* (Amer. Mus. 19720) from 41 to 44 of these cones and conelets may be counted. Consequently the whole surface of the crown (Figs. 623, 631, 632) becomes crowded with a labyrinthine pattern of cones, conelets, and more or less separate intermediate conelets, with warped or dislocated ridge-crests in apparent disorder, giving the appearance best

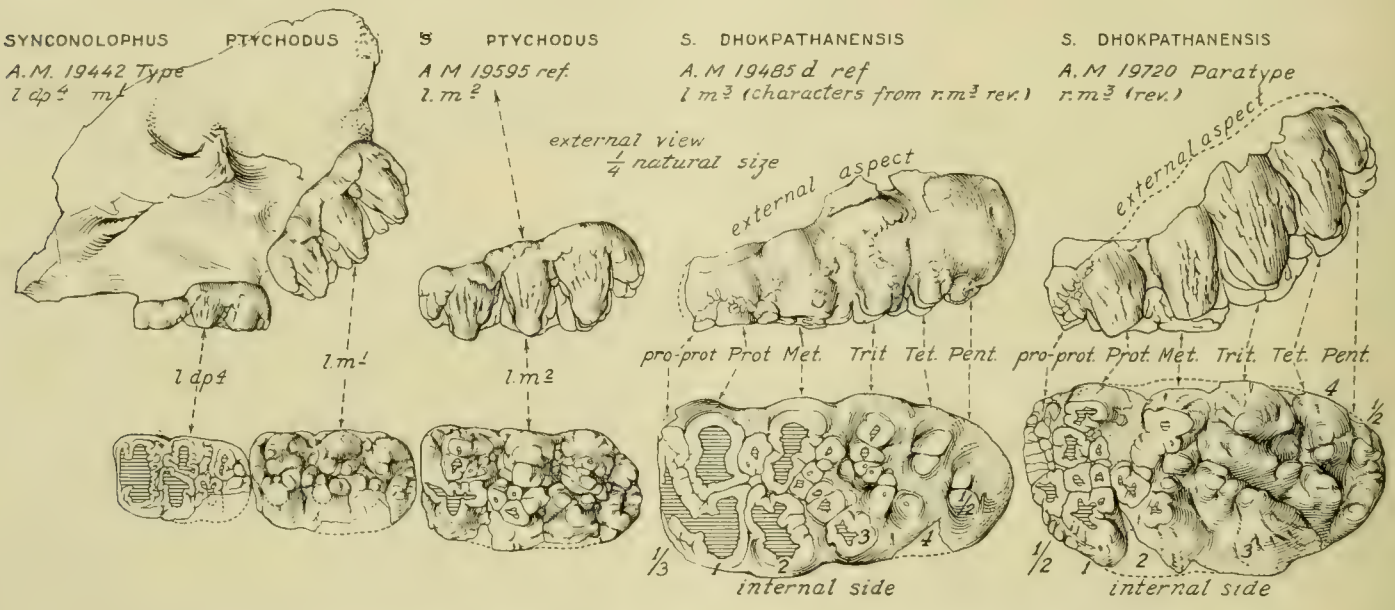


Fig. 623. Synconolophus ptychodus (Lower Chinji) and S. dhokpathanensis (Dhok Pathan)

All figures one-fourth natural size

Lower Chinji horizon, 800 feet above base of Lower Siwaliks, India.

Synconolophus ptychodus Osborn, type (Amer. Mus. 19442). Fragment of juvenile left maxilla containing l.Dp^4, l.M^1. Compare figure 624, crown view of same type molar, l.M^1.

Lower Chinji horizon, 2,000 feet above base of Lower Siwaliks, India.

Synconolophus ptychodus ref. (Amer. Mus. 19595). A second superior molar of the left side, l.M^2. Compare figure 625 for crown view of same referred molar, l.M^2.

Dhok Pathan horizon, 500 feet below top of Middle Siwaliks, India.

Synconolophus dhokpathanensis ref. (Amer. Mus. 19485*d*). Composite drawing of third superior molar, l.M^3. (Upper) external aspect; (lower) crown aspect, exhibiting the pro-protoloph (pro-prot.), the proto-, meta-, trito-, tetarto-, and pentalophs.

Synconolophus dhokpathanensis paratype (Amer. Mus. 19720). Reversed drawing of unworn third right superior molar, r.M^3. (Upper) external aspect; (lower) crown aspect. Compare figure 631 for crown view of same grinding tooth.

expressed in the Greek generic term *Synconolophus*. The specific name *dhokpathanensis* refers to the great Dhok Pathan horizon of the Middle Pliocene, Middle Siwaliks, which is regarded as subsequent to the geologic age of Pikermi and Eppelsheim.

Progressive Stage.—The giant *Synconolophus dhokpathanensis* of Middle Pliocene age is a very progressive species which possibly represents the end of this generic phylum; it is represented in the American Museum collection by a complete type cranium (Figs. 629, 630), by a paratype (Figs. 623, 631), and by referred specimens (Fig. 632) which display the characters of the grinding teeth, also by fragmentary remains of other grinders, all of which show the same extreme characters and are totally unlike any other mastodont teeth hitherto discovered.

PRIMITIVE STAGE. –The much smaller *Synconolophus ptychodus* Osborn is of Mio-Pliocene age. Fortunately in the much older Lower Chinji horizon, extending from the low level of 400 feet above the base of the Lower Siwaliks, near Chinji Bungalow, to 2,000 feet above the base, was found a series of progressive stages or *ascending mutations* in the specific stage *Synconolophus ptychodus*, of much smaller, more primitive, and simpler character. The specific name *ptychodus* refers to the grooving (Fig. 623) on the sides of the type (Amer. Mus. 19442) and referred (Amer. Mus. 19595) grinding teeth. In the grinders, of which the fourth milk premolar, l.Dp^4, and the first and second superior molars, l.M^1, l.M^2, are best preserved, the internal and external pairs of cones and conelets are seen to be opposite instead of alternate, the crests are nearly transverse instead of warped or dislocated; the contrast is very clearly shown in an examination of the contiguous crown of *S. ptychodus* (left) and of *S. dhokpathanensis* (right) in figure 623.

Synconolophus ptychodus Osborn, 1929

Figures 623–625

Lower Chinji horizon, 800 feet above the base of the Lower Siwaliks, 4 miles west of Chinji Bungalow, India. Mio-Pliocene.

TYPE AND REFERRED MATERIALS.—The geologic level records of the type and four referred specimens are as follows, beginning with the lower 400 foot level and rising to the 2,000 foot level and even to 1,000 feet below the Bhandar bone bed:

LOWER MIDDLE PLIOCENE

Lower Middle Siwaliks 1,000 feet below Bhandar bone bed, 5 m. west of Hasnot	Amer. Mus. 19533 ref. Posterior half of l.M$_3$ with tetarto- and pentalophids, hexalophid rudimentary.

MIO-PLIOCENE

Lower Chinji horizon 2,000 feet above base of Lower Siwaliks, 3 m. west of Chinji Bungalow	Amer. Mus. 19595 ref. Left second superior molar, l.M^2. Figure 623 shows lateral and crown aspects.
Lower Chinji horizon 800 feet above base of Lower Siwaliks, 4 m. west of Chinji Bungalow	Amer. Mus. 19442 type. Fragment of left maxilla with l.Dp^4, l.M^1. The type figure (Fig. 623) displays lateral and crown aspects of l.Dp^4 and l.M^1.
Lower Chinji horizon 400 feet above base of Lower Siwaliks, 4 m. northeast of Chinji Bungalow	Amer. Mus. 19638a ref. Left first inferior molar, l.M$_1$. Amer. Mus. 19638b ref. Right first inferior molar, r.M$_1$.
Lower Chinji horizon 400 feet above base of Lower Siwaliks, 2 m. west of Chinji Bungalow	Amer. Mus. 19628 ref. Posterior half of l.M$_3$, with trito-, tetarto-, and pentalophids, hexalophid rudiment lacking.

SPECIFIC CHARACTERS.—(FIGS. 623, 624).—Three ridge-crests of the first superior molar, l.M^1, with strong cingulate pro-protoloph and half rudiment of tetartoloph; internal and external cones ptychoid on outer faces and on inner worn surfaces; internal cones slightly anterior to external cones, not directly opposite; median anterior and posterior trefoil conelets on either side of internal cones, less prominent trefoil conelets on either side of external cones, summits of transverse crests divided into four to five separate conelets.

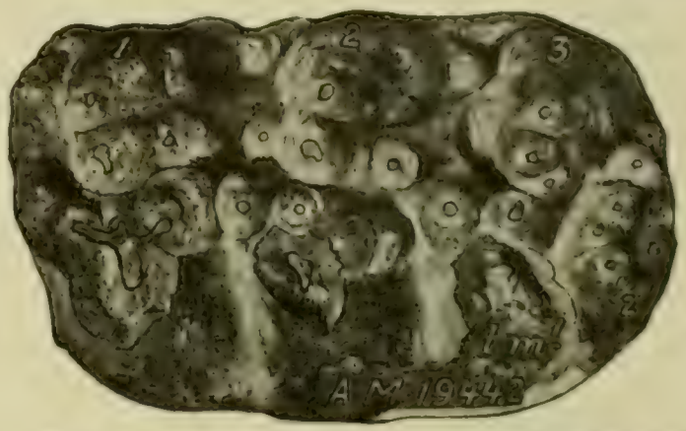


Fig. 624. *Synconolophus ptychodus* Osborn, type (Amer. Mus. 19442). Crown view of first superior molar of the left side, l.M^1, reproduced natural size. Compare figure 623 for type maxilla.

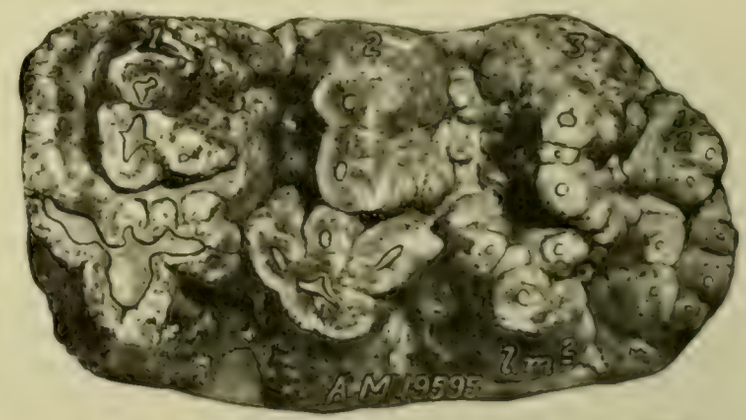


Fig. 625. Referred *Synconolophus ptychodus* (Amer. Mus. 19595). A second superior molar of the left side, l.M^2, reduced to four-fifths natural size. Compare figure 623.

The juvenile dentition of *Synconolophus ptychodus* and *S. dhokpathanensis*, including l.Dp^4, is described and figured in detail above (Fig. 623), showing that these molars are highly chœrodont, that is, covered with closely compacted cones, conules, and conelets.

REFERRED MUTATIONS.—These type molars of the Lower Chinji horizon, 800 feet above the base of the Lower Siwaliks, display in larger size and to an exaggerated degree the characters observed in the more primitive *Synconolophus ptychodus* ref. (Amer. Mus. 19638a, l.M$_1$, and Amer. Mus. 19638b, r.M$_1$) found

400 feet above the base of the Lower Siwaliks, also of the Lower Chinji horizon.

Of larger size is the *Synconolophus ptychodus* ref., a second superior molar, l.M² (Amer. Mus. 19595—Figs. 623, 625); in this grinder (ap. 121 mm., tr. 68 mm., height of metaloph 52 mm.) the specific characters of *S. ptychodus* are still more pronounced, namely, strong pro-protoloph, more prominent rudimentary tetartoloph, proto-, meta-, and tritolophs strongly ptychoid on outer faces, with strong internal trefoil conelets and low external trefoil conelets; these internal and external trefoil conelets are ancestral to the five trefoil conelets compressed between the transverse crests of *Synconolophus dhokpathanensis* ref. (Amer. Mus. 19485*d*—Fig. 623), also in the paratype (Amer. Mus. 19720—Fig. 623). Consequently the *S. ptychodus* superior and inferior molar crowns are *ancestral* to the *S. dhokpathanensis* superior and inferior molar crowns; they are much more primitive and simple, because they do not exhibit the marked warping or dislocation of the transverse crests which characterize the larger and more recent species *S. dhokpathanensis.*

General Characters.—(1) *Synconolophus ptychodus* is smaller, more primitive, with more transversely placed cones and fewer intermediate trefoil conelets in the valleys than in its highly specialized successor *S. dhokpathanensis;* (2) included for the present within this single species are three ascending mutations, namely, two very small and simple molars (Amer. Mus. 19638a, b), from 400 feet above the base of the Lower Siwaliks, the larger and more complex type molars (Amer. Mus. 19442) from 800 feet above the base of the Lower Siwaliks, and finally the still more progressive molar, an l.M² (Amer. Mus. 19595), from 2,000 feet above the base of the Lower Siwaliks, all from the Lower Chinji level of Pilgrim. (3) Referable to this smaller stage, but also recorded as having been found 400 feet above the base of the Lower Siwaliks, is an l.M₃ (Amer. Mus. 19628). From a still higher level than the Lower Chinji horizon, 1,000 feet *below* the Bhandar bone bed, is another l.M₃ (Amer. Mus. 19533).

Type and Referred Synconolophus ptychodus Comparative Measurements in Millimeters

	Dp 4			M 1			M 2			M 3	Height
Superior Molars	ap.	tr.	I.	ap.	tr.	I.	ap.	tr.	I.	tr.	Metaloph
Amer. Mus. 19442 type, left	72	44	61	93	59	63					
Amer. Mus. 19595 ref., left							121	68	56		52
Inferior Molars											Tetartolophid
Amer. Mus. 19628 ref., left										74	49
Amer. Mus. 19533 ref., left										68	46
Amer. Mus. 19638a, ref., left				78	44e	56e					
Amer. Mus. 19638b, ref., right				73	37	51					

Synconolophus corrugatus Pilgrim, 1913

Figures 581, 593, 621, 622, and 626

From Hasnot, India, Dhok Pathan horizon, Middle Pliocene, post-Pikermi age.

Compare *Mastodon* (*Trilophodon*) *pandionis* ref., Lydekker, 1880, Pl. xxxv, fig. 4.

As shown in the diagrammatic comparison (Fig. 622), the type of '*Tetrabelodon*' *corrugatus* Pilgrim is generically related to the type of '*Mastodon*' *hasnoti* Pilgrim and to the type of *Synconolophus dhokpathanensis* Osborn. Pending further close comparison and research, the uncertainty as to the structure of the lower jaw (Fig. 626) and apparent differences in the third inferior grinders (Fig. 622) appear to separate these three types specifically. The following successive observations (1–4) during the preparation of this Memoir were made by the present author.

History.—(1) A comparison of the types of *Tetrabelodon corrugatus* Pilgrim, 1913, and *Mastodon hasnoti* Pilgrim, 1913, shows that these molars are wholly unlike the type of *Mastodon brevirostris* Gervais and de Serres, 1846 (Fig. 597); *T. corrugatus* and *M. hasnoti* bear more resemblance to the grinding teeth of *Stegomastodon* (Fig. 645) and of *Synconolophus* (Fig. 632). (2) The type grinding tooth (Fig. 626) to which Pilgrim applied the name '*Tetrabelodon*' *corrugatus* is from the same Dhok Pathan horizon as the type of '*Mastodon*' *hasnoti*, described in the same paper immediately thereafter. It belongs to the Brevirostrines, either to the phylum *Synconolophus* or to the phylum *Anancus*, as is evident from the extreme alternation of the cones and the obliquity of the ridge-crests; ridge-crest formula M 3 $\frac{}{5\frac{1}{2}}$. (3) The corrugation of the type cones and ridges resembles that of the outer surface of the upper milk teeth (Fig. 587) of '*Mastodon*' [=*Anancus*] *arvernensis* [=*falconeri*] from the Norwich Crag, also of the milk teeth (Fig. 596) of the '*M.*' [=*Anancus*] *arvernensis* type. It will be observed, however, that the grooves of the enamel ridges are becoming deeply infolded or ptychoid and that the crown begins to suggest the labyrinthine foldings of the *Stegomastodon* molar. (4) This 5½ crested grinding tooth of *Synconolophus corrugatus* should also be compared with the 4+crested paratype grinding tooth of *S. dhokpathanensis* (Fig. 631) and of the referred *S. ptychodus* (Fig. 623).

Tetrabelodon corrugatus Pilgrim, 1913. "The Correlation of the Siwaliks with Mammal Horizons of Europe." Rec. Geol. Surv. India, Vol. XLIII, Pt. 4, p. 293. Type.—(Lydekker, 1880, Pl. xxxv, fig. 4): "The third right lower true molar: from the Punjab." (Lydekker, 1885, p. 100): Ind. Mus. "A.98. Symphysis and part of the right ramus of the mandible; from Asnot. The last true molar is *in situ* and is figured [as *Mastodon* (*Trilophodon*) *pandionis*] in the 'Pal. Ind.' *op. cit.* [1880] vol. i., pl. xxxv., fig. 4; the symphysis (which is tuskless) being figured in pl. xxxvi., fig. 1. *Collected by Mr. Theobald.*" Horizon and Locality.—Hasnot, India, Dhok Pathan horizon, Middle Pliocene. Type

FIGURE.—Figured by Lydekker (1880, Pl. xxxv, fig. 4) as "*Mastodon* (*Trilophodon*) *pandionis.*" See also Lydekker, 1880, Pl. xxxvi, fig. 1.

LYDEKKER (1880), PILGRIM (1913).—The type specimens refigured below were originally referred by Lydekker (1880, Pl. xxxvi, fig. 1, and Pl. xxxv, fig. 4) to *Mastodon pandionis;* they were selected for type description by Pilgrim (1913, pp. 292, 293) as follows:

TYPE DESCRIPTION (PILGRIM, 1913, PP. 292, 293).—In his original description of this species [i.e., '*Tetrabelodon*' *corrugatus*], Pilgrim (1913, p. 292) observed: "In the Dhok Pathan zone its existence is clearly proved by the beautiful specimen of a mandible from Hasnot, which R. Lydekker figured [erroneously] with its extended symphysis under the name of *Mastodon pandionis.* . . . That the specimen [i.e., the type of *T. corrugatus*] is of very much greater age than anything in the Middle Siwaliks is indicated by its strong resemblance, though in a more advanced stage of development to specimens obtained from the upper aquitanian of the Bugti Hills by C. Forster Cooper. Further, the first dentition of *Anancus:* widely differing from that in *Anancus arvernensis.* Ridge-crest formula, M 3 $\frac{}{5\frac{1}{2}}$, similar to that of primitive species of *Stegomastodon.* Two or three of the *internal* cones and conelets slope obliquely backwards, intermediate conelets behind tritolophid.

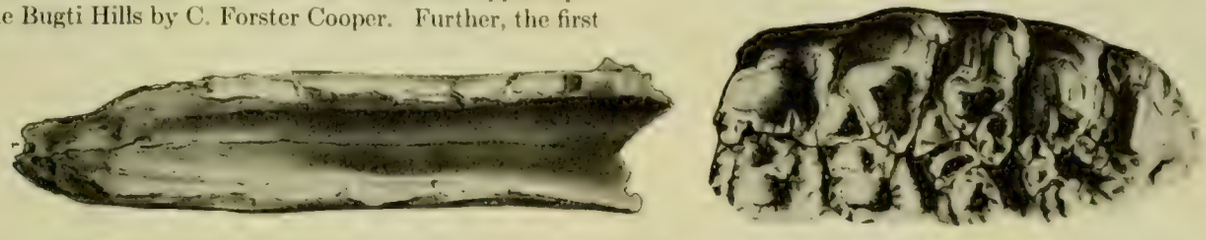
From the above definition and from a comparison of the type of '*Tetrabelodon*' *corrugatus* with the type of *Synconolophus dhokpathanensis*, it appears certain that this Indian species belongs to the *Synconolophus* phylum.

Synconolophus hasnoti Pilgrim, 1913

Figures 581, 621, 622, 627, and 628

From near Bhimbar, northwest of Jammu, India, Dhok Pathan horizon, Middle Pliocene, post-Pikermi age.

The type of *Synconolophus hasnoti* (Figs. 622, 627) is readily interpreted by means of a comparison with the type of *S. corrugatus* (Figs. 622, 626) and with a referred specimen of *S. dhokpathanensis*



INFERIOR GRINDER OF SYNCONOLOPHUS CORRUGATUS TYPE, HASNOT, DHOK PATHAN HORIZON, MIDDLE PLIOCENE

Fig. 626. Type corrugated grinding tooth of *Tetrabelodon corrugatus* Pilgrim, 1913, described as follows by Lydekker (1885, p. 100): Ind. Mus. "A.98. Symphysis and part of the right ramus of the mandible; from Asnot. The last true molar [r.M_3] is *in situ* and is figured [as *Mastodon* (*Trilophodon*) *pandionis*] in the 'Pal. Ind.' *op. cit.* [1880] vol. i., pl. xxxv., fig. 4; the symphysis (which is tuskless) being figured in pl. xxxvi., fig. 1. *Collected by Mr. Theobald.*" The type grinder (right) is figured one-third natural size (206 mm. = 8.1 in. × 91 mm. = 3.6 in); the symphysis one-sixth natural size.

The fractured longirostrine symphysis (left) is not of the brevirostrine form which we should expect to find with the cranium of *Synconolophus* (Figs. 629, 630); this may be a case of erroneous field association; see, however, trough-shaped symphysis of *Synconolophus propathanensis* (Fig. 633), of *Anancus perimensis* (Fig. 610).

and second molars of the Dhok Pathan species differ in structure from the type of *T. pandionis.* It is necessary, therefore, that a new name should be given to the Dhok Pathan species and as the wrinkling of the enamel is a very striking feature I propose for it the name of *Tetrabelodon corrugatus.* This is a trilophodont mastodon, like *Tetrabelodon pentelici.*"

Osborn, 1924: It appears doubtful whether the elongated longirostrine symphysis really belongs with this type brevirostrine grinding tooth, although Lydekker and Pilgrim associate the long, narrow symphysis (Fig. 626, left) and the right grinding tooth (Fig. 626, right). Lydekker referred these two specimens to *Mastodon* (i.e., *Trilophodon*) *pandionis.* Pilgrim confirmed Lydekker's reference by stating: "This is a trilophodont mastodon, like *Tetrabelodon pentelici.*" The type molar tooth is five and a half crested with closely compacted cones and conelets. Eliminating the elongated symphysis, the specific characters displayed in the grinding teeth are as follows.

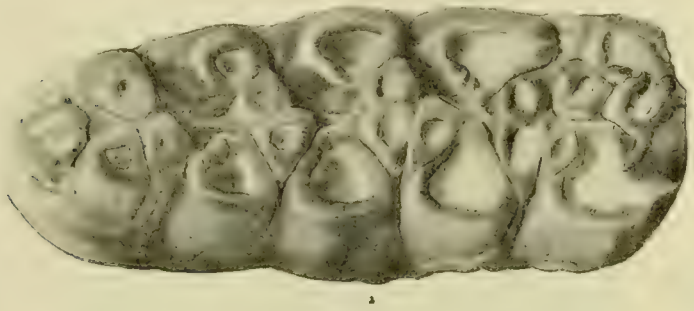
SPECIFIC CHARACTERS.—Ridge-crests in third inferior molar, M 3 $\frac{}{5\frac{1}{2}}$; enamel of cones and conelets deeply corrugated and plicated both on inner and outer surfaces; cones and conelets closely compressed so as to produce a 'chœrodont' grinding surface resembling that in *Stegomastodon mirificus* also that in the milk (Figs. 622, 632); each of the five transverse crests consists of large internal and external conelets with smaller intermediate conelets pressed forwards; apparently there are supplementary intermediate conelets on the proto- and metalophids; in all 24 conelets may be counted on this crown.

HISTORY.—This species was termed in 1880 *Mastodon* (*Tetralophodon*) *sivalensis* by Lydekker (1880, Pl. xliv) and in 1913 was distinguished by Pilgrim as "tetralophodont," with four crested intermediate molars, and regarded by him as a direct ancestor of '*Mastodon*' *arvernensis* of the Upper Pliocene. Pilgrim described *Mastodon hasnoti* immediately after his description of *Tetrabelodon corrugatus,* under the impression that it belonged to a distinct genus.

GEOLOGIC AGE.—Pilgrim placed his type of *Mastodon hasnoti* in the Middle Pliocene Dhok Pathan horizon (see Geologic Tables of 1935—Figs. 413, 414 of the present Memoir), but there may be some mistake in the record, because Lydekker originally described the same type specimen as from the Punjab and later as from near Bhimbar, northwest of Jammu.

Mastodon hasnoti Pilgrim, 1913. "The Correlation of the Siwaliks with Mammal Horizons of Europe." Rec. Geol. Surv. India, XLIII, Pt. 4, p. 293. TYPE.—(Lydekker, 1880, Pl.

XLIV, fig. 3): "Third right lower true molar: from a nearly complete palate [mandible], collected in the Punjab." (Lydekker, 1885, p. 93): Ind. Mus. "A.104. Symphysial portion of the mandible, containing the third true molar of either side; from near Bhimbar (N. W. of Jamu). The tooth of the right side is figured [Footnote: 'In the description of the plate the word *palate* is given in place of *mandible*.'] in the 'Pal. Ind.' ser. 10, vol. i., pl. xliv., fig. 3; it is very like a specimen figured in the 'F. A. S.' pl. xxxvii., fig. 7, but the ridges are one less in number, and the alternate arrangement of the columns is not so strongly marked; the enamel is quite smooth. The left side of the specimen is crushed in, and the tooth bent inwards. *Collected by Mr. Theobald.*" HORIZON AND LOCALITY.—From near Bhimbar (northwest of Jammu), India, Dhok Pathan horizon, Middle Pliocene. TYPE FIGURE.—Figured by Lydekker (1880, Pl. XLIV, fig. 3) as "*Mastodon (Tetralophodon) sivalensis.*"



SYNCONOLOPHUS HASNOTI TYPE, MIDDLE PLIOCENE

Fig. 627. Type figure of *Mastodon hasnoti* Pilgrim, 1913. After Lydekker, 1880, Pl. XLIV, fig. 3: "*Mastodon (Tetralophodon) sivalensis. . . .* Third right lower true molar: from a nearly complete palate [mandible], collected in the Punjab." The species *M. hasnoti* Pilgrim takes its name from Hasnot, Salt Range, Dhok Pathan horizon, India. One-half natural size. Ind. Mus. A.104.

TYPE DESCRIPTION.—(Cf. Pilgrim, 1913, p. 293): Side by side in the Dhok Pathan zone with *Tetrabelodon punjabiensis* (cf. *T. pentelici* of Pikermi, *T. longirostris*, and *T. corrugatus*) occurs the type of *M. hasnoti* which Pilgrim (1913, p. 293) compares with '*M.*' *arvernensis* of the lignites of Casino. "This is the species [specimen], which Lydekker has figured in Pal. Ind., ser. 10, Vol. I., Plate 44, under the name of *Mastodon sivalensis.* As Lydekker himself has pointed out, the Middle Siwalik species differs from Falconer's *M. sivalensis* of the Upper Siwaliks (1) by being tetralophodont instead of pentalophodont, (2) by having the alternation of the columns very slightly marked. I therefore propose that the Middle Siwalik species be known as *Mastodon hasnoti.*"

Osborn, 1924: Comparison of this type third lower molar of the right side, r.M_3, with corresponding teeth of the type of *Anancus arvernensis* or of its synonym *A. brevirostris* in France, does not sustain Pilgrim's observation that this species is a direct ancestor of '*Mastodon*' *arvernensis*, although it is an undoubted Brevirostrine. The alternation of the inner and outer cones is well marked and there are four conelets on each of the obliquely placed transverse ridge-crests, clearly seen in the tritolophid and the tetartolophid; the cones and conelets are closely compressed, giving the crown a chœrodont grinding character, much more labyrinthine in pattern than that of *Anancus arvernensis;* in all we may count twenty-four cones and conelets on this complicated surface, showing that this tooth was entirely given over to grinding action. It was figured natural size by Lydekker, and measures ap. 185 mm. by tr. 77 mm., with an index of 42.

PHYLOGENETIC RELATIONSHIPS (OSBORN, 1928).—While this type molar of *Synconolophus hasnoti* has the same ridge-crest formula, namely, M 3 $\frac{}{5\frac{1}{2}}$, as the type of '*Tetrabelodon*' *corrugatus*, the corrugation of the cones and conelets is much less pronounced; the tooth is also relatively longer and narrower than the type of '*T.*' *corrugatus.* The alternation of the internal and external cones thoroughly sustains Pilgrim's reference of this species to relationship with '*Mastodon*' *arvernensis.* It is not, however, ancestral to '*M.*' *arvernensis*, because the cones and conelets are too closely compressed and crowded; it agrees in these characters with '*Tetrabelodon*' [=*Synconolophus*] *corrugatus* and may be regarded as a primitive stage or ascending mutation leading up to *Synconolophus corrugatus* and *S. dhokpathanensis.*

Fig. 628. Juvenile cranium of *Synconolophus hasnoti* (Amer. Mus. 19462), recorded by Barnum Brown as discovered about 500 feet below top of Middle Siwaliks, one-half mile east of Dhok Pathan, India. One-sixth natural size.

A synopsis of differences (Figs. 622, 631) appears to be as follows:

Synconolophus hasnoti type

Meas. of M_3: ap. 185, tr. 77, I. 42.

Cones simple, not corrugated.

Single intermediate conelet on proto- and metalophids only. Total inferior conelets 24.

Warping of transverse ridge-crests relatively slight.

Ridge formula: M 3 $\frac{}{5\frac{1}{2}}$.

Synconolophus corrugatus type

Meas. of M_3: ap. 206, tr. 91, I. 44.

Cones and conelets grooved externally.

Intermediate conelets behind tritolophid. Total inferior conelets 24+.

Warping or alternation of opposite cones relatively slight.

Ridge formula: M 3 $\frac{}{5\frac{1}{2}}$.

Synconolophus dhokpathanensis paratype

Meas. of M^3: ap. 200, tr. 106, I. 53.

Cones deeply grooved. Enamel ptychoid.

Single intermediate conelet on metaloph. Cement strongly developed. Total superior conelets 41–44.

Ridge formula: M 3 $\frac{4\pm}{}$.

Fig. 629. Type cranium of *Synconolophus dhokpathanensis* Osborn (Amer. Mus. 19673), discovered in the Dhok Pathan horizon, 500 feet below the top of the Middle Siwaliks. One-eighth natural size.

Observe especially (1) in the partly restored molar crowns, M^2, M^3, the strong backward warping or dislocation of the *internal* cones and conelets, whereas the external cones and conelets are in normal position; (2) the posterior position of the internal narial opening, far behind the posterior border of the superior grinders; (3) observe also the ridge-crest formula, namely, M2 $\frac{3\frac{1}{2}}{}$ M3 $\frac{1\frac{1}{2}\text{-}4\text{-}1\frac{1}{2}}{}$. For the true characters and proportions of the grinding teeth, compare figures 623, 631, and 632. For the structure and proportions of the cranium as a whole, compare figure 630. For the contrast which this palate affords with *Tetralophodon punjabiensis*, compare figures 305, 306.

Synconolophus dhokpathanensis Osborn, 1929

Figs. 583, 621–623, 629–632

Type skull discovered by Barnum Brown three miles west of Dhok Pathan, 500 feet below the top of the Middle Siwaliks, Middle Pliocene, on the same level as the *Hipparion punjabiense* (?) ref. quarry, also on the same level as the cranium of *Tetralophodon punjabiensis* (Amer. Mus. 19686).

Compare *Tetrabelodon corrugatus* and *Mastodon hasnoti* Pilgrim, 1913.

This species should first be compared (Fig. 622) with the types of other Brevirostrines from the same Dhok Pathan horizon, namely, '*Tetrabelodon*' *corrugatus* Pilgrim, 1913 (Fig. 626) and '*Mastodon*' *hasnoti* Pilgrim, 1913 (Fig. 627), which present strong generic if not specific resemblance in the structure of the third inferior molar teeth to *Synconolophus dhokpathanensis*.

	ap.	tr.	I.
Type r.M_3 of '*T.*' *corrugatus* Pilg.	206	91	44
Type r.M_3 of '*M.*' *hasnoti* Pilg.	185	77	42
Ref. r.M_3 of *S. dhokpathanensis* Osb.	202e	86e	43e

According to the comparisons herewith, *Synconolophus dhokpathanensis* is the most progressive species of the Dhok Pathan horizon, succeeding the two somewhat simpler stages *S. corrugatus* and *S. hasnoti*. In case further material should demonstrate specific resemblance, *S. dhokpathanensis* might become a synonym of *S. corrugatus*.

Synconolophus dhokpathanensis Osborn, 1929.—Amer. Mus. Novitates, No. 393, 1929, p. 10. Type.—"Cranium with portions of right and left superior tusks, and M^2, M^3, of both sides *in situ*." Type and Paratype Figures.—*Op. cit.*, 1929.797, figs. 10, 11.

Description of Type Cranium (Figs. 629, 630).—The fully adult cranium (Amer. Mus. 19673, Field No. 40) was discovered by Barnum Brown 500 feet below the top of the Middle Siwaliks, on the same geologic level as the specifically distinct cranium known as *Tetralophodon punjabiensis* (Amer. Mus. 19686).

Unlike *Anancus arvernensis* the superior tusks curve sharply upwards and outwards, thus agreeing closely in form and curvature with the superior tusks of *Stegomastodon* of Nebraska and Texas, a very marked generic distinction from *Anancus*. The right tusk is abnormally curved upwards and backwards.

Unfortunately the aged grinding teeth of the type are badly damaged, so that it is difficult to determine the ridge formula with precision. As shown in the type figure (Fig. 630 A1), the ridge formula is apparently as follows: r.M 2 $\frac{3\frac{1}{2}}{}$, r.M 3 $\frac{1\frac{1}{2}\text{-}4\text{-}1\frac{1}{2}}{}$.

A generic distinction of *Synconolophus* from *Tetralophodon* is the relatively elongated palate and backwardly placed posterior nares; in this character *S. dhokpathanensis* (Fig. 630 A1) agrees closely with *Stegomastodon texanus* (Fig. 639 A1). Consequently this cranium establishes an important new fact, namely, the presence of the distinct *Synconolophus* phylum of the Brevirostrinæ in India, contemporaneous with the *Tetralophodon* phylum.

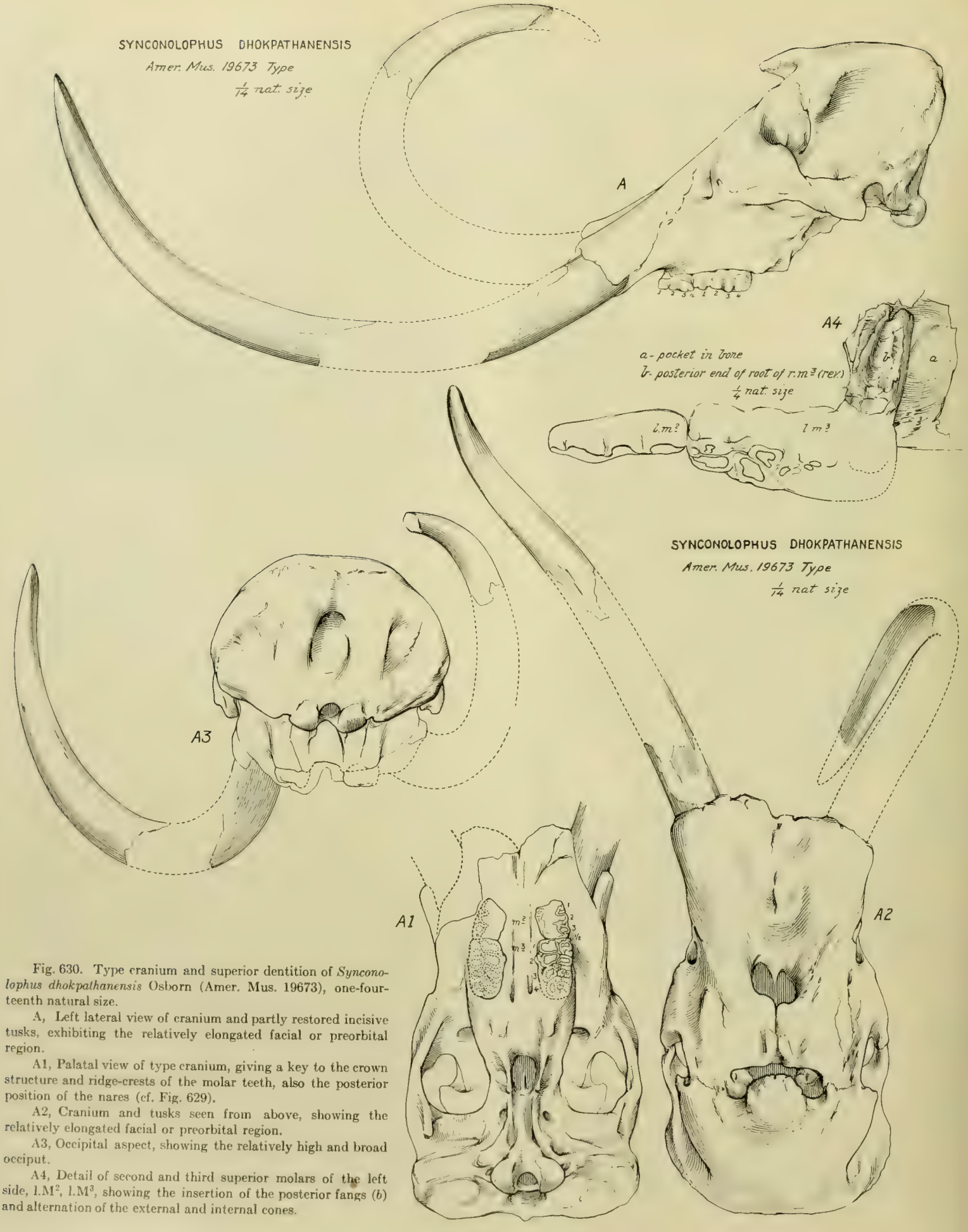


Fig. 630. Type cranium and superior dentition of *Synconolophus dhokpathanensis* Osborn (Amer. Mus. 19673), one-fourteenth natural size.

A, Left lateral view of cranium and partly restored incisive tusks, exhibiting the relatively elongated facial or preorbital region.

A1, Palatal view of type cranium, giving a key to the crown structure and ridge-crests of the molar teeth, also the posterior position of the nares (cf. Fig. 629).

A2, Cranium and tusks seen from above, showing the relatively elongated facial or preorbital region.

A3, Occipital aspect, showing the relatively high and broad occiput.

A4, Detail of second and third superior molars of the left side, l.M^2, l.M^3, showing the insertion of the posterior fangs (*b*) and alternation of the external and internal cones.

PRINCIPAL MEASUREMENTS OF CRANIUM IN MILLIMETERS (FIGS. 629, 630)

Total zygomatic width	720
Condyle to extremity of alveolus	1080
Breadth-length index	67
Height of occiput above condyles	850
Width of occiput	740
Posterior nares behind third molar,	
horizontal	150
oblique	250
Length of left tusk on outer curve	2311 = 7 ft. 7 in.
Length of right tusk on outer curve	1945 = 6 ft. 4½ in.

but the fluting on the outer surfaces of the cones is not so marked as in the large, highly fluted paratype, r.M³ (Amer. Mus. 19720).

PARATYPE THIRD RIGHT SUPERIOR MOLAR OF SYNCONOLOPHUS DHOKPATHANENSIS (FIGS. 623, 631)

SUPERIOR R.M³.—Paratype crown (Amer. Mus. 19720), damaged and restored on sides with plaster. Pro-protoloph, tr. 65 mm.; six plus irregular conelets lessening in size externally, large ptychoid internal conelet. Protoloph, tr. 100 mm.; four main conelets transversely arranged, three posterior conelets. Metaloph, tr. 100+mm.; obliquely warped internal pair of ptychoid conelets, external pair transverse, four large and three small posterior

TYPE, PARATYPE, AND REFERRED MOLAR MEASUREMENTS, IN MILLIMETERS (FIGS. 623, 629–632) OF SYNCONOLOPHUS DHOKPATHANENSIS

	Type (Amer. Mus. 19673)				Paratype (Amer. Mus. 19720)	Referred (Amer. Mus. 19485*b*, *d*)	
	Left M²	Right M²	Left M³	Right M³	Right M³	Right M³	Left M³
Anteroposterior	116	119	179	176	200	190e	190e
Transverse at							
protoloph	88		92	95	100	89e	
metaloph		95	103	103	100+	94e	91e
tritoloph			99	91	106	90e	89e
tetartoloph			89	84	92	79e	79e
pentaloph					77		

REFERRED THIRD RIGHT AND LEFT SUPERIOR AND INFERIOR MOLARS OF SYNCONOLOPHUS DHOKPATHANENSIS (AMER. MUS. 19485A–D) FROM THE DHOK PATHAN HORIZON, 500 FEET BELOW TOP OF MIDDLE SIWALIKS, INDIA

SUPERIOR L.M³ AND R.M³ (AMER. MUS. 19485B, D—FIGS. 623, 632).—Crown partly fractured (Fig. 632), of size intermediate between type (Amer. Mus. 19673) and paratype (Amer. Mus. 19720); pro-protoloph fractured, proto- and metalophs much more worn (Fig. 632), exposing large external and internal cones, two conelets behind protoloph, four to five conelets behind metaloph; internal cones and conelets of meta-, trito-, and tetartolophs strongly warped or dislocated backwards as in the type (Amer. Mus. 19673) and in the paratype (Amer. Mus. 19720). Diameters (ap. 190e mm., tr. 94e mm.) comparable to those of paratype (Amer. Mus. 19720).

INFERIOR MOLARS (AMER. MUS. 19485 C, A—FIG. 632).—This lower pair of relatively long, narrow molars (diameters, ap. 202e mm., tr. 86e mm.) exhibits five and a half ridge-crests with strongly warped external cones and conelets of the four posterior crests (2–3–4–5), as shown in the figure of r.M₃; the protolophid (tr. 74 mm.) is worn off in both molars; the metalophid (tr. 83 mm.) consists of four large conelets, the inner pair warped, and small intermediate conelet; the tritolophid consists of four large and separate conelets, the outer pair warped, no intermediate conelets. The tetartolophid consists of three main conelets, the outer two being strongly warped; the pentalophid (fifth crest) consists of two main cones; the rudimentary hexalophid (½) consists of a single cone. A heavy cement layer surrounds the cones and conelets of r.M₃ (Fig. 632), and the anterior crests of r.M³ (Fig. 632). The heavy enamel of the cones and conelets is ptychoid or fluted, conelets compressed at summit. Tritoloph, tr. 106 mm., still more strongly warped or dislocated on internal side; internal and external pairs of cones transverse, two posterior conelets. Tetartoloph, tr. 92 mm.; narrow, laterally compressed, one internal warped cone, two external transversely placed conelets. Pentaloph, tr. 77 mm.; transversely crested, nine vertical posterior grooves; height 53e mm., as compared with height of tritoloph, 89e mm. Cones larger and more highly fluted on the sides (Fig. 623); cement preserved only in the bottom of the valleys, as compared with the referred specimen (Amer. Mus. 19485c—Fig. 632).

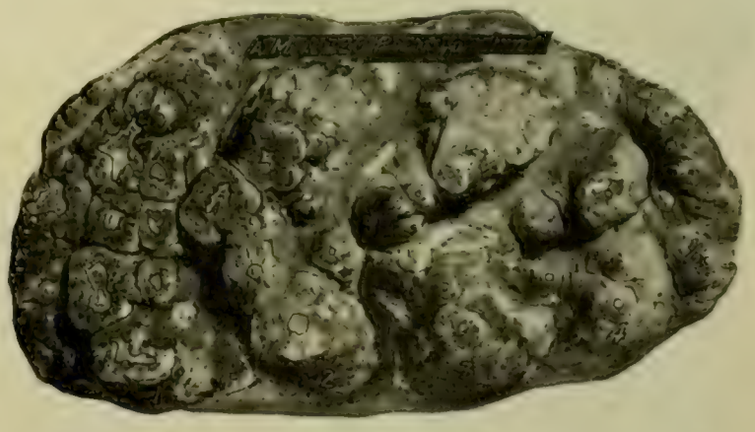


Fig. 631. Paratype of *Synconolophus dhokpathanensis* (Amer. Mus. 19720) found approximately 500 ft. below top of Middle Siwaliks, same level as *Hipparion* quarry, Dhok Pathan. A third superior molar of the right side, r.M³, reduced to one-half natural size. Compare figure 623. Observe pro-protoloph and (1–4) proto-, meta-, trito-, and tetartolophs, also (½) rudimentary pentaloph.

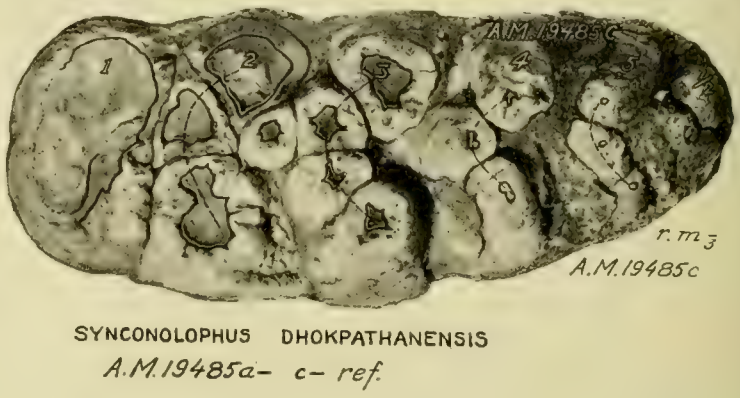
Fragmentary Molars of Other Individuals from Same Level

Synconolophus dhokpathanensis Ref.

(1) Amer. Mus. 19462. Referred juvenile cranium containing fractured bases of three superior milk teeth, Dp^2, Dp^3, Dp^4, and crowns of $l.M^1$ and $r.M^1$, also embedded crown of $r.M^2$ and $l.M^2$; recognized as *Synconolophus dhokpathanensis* by the strongly warped or dislocated internal cones of M^1, differing by the anterior position of the posterior narial opening, in contrast to the posterior position of the same in the adult type cranium (Amer. Mus. 19673—Fig. 629). Space occupied by three milk premolars, Dp^2, Dp^3, Dp^4, 145 mm. First molar, $l.M^1$, ap. 96 mm., tr. 65 mm. Ridge-crests: ¼–3–⅓. Internal cones of proto-, meta-, and tritolophs increasingly warped or dislocated; multiple irregular conelets crowning each loph, posterior intermediate conelets on proto- and metalophs, as in adult paratype M^3 (Amer. Mus. 19720) and referred M^3 (Amer. Mus. 19485b). (2) Amer. Mus. 19485f, outer half of tritoloph, warped tetartoloph, and perfect pentaloph of $r.M^3$. (3) Amer. Mus. 19927, warped internal cones of tritoloph of $l.M^3$.

Stegolophodon stegodontoides Ref.

Amer. Mus. 19485e. Anterior portion of superior molar crown of $l.M^3$.



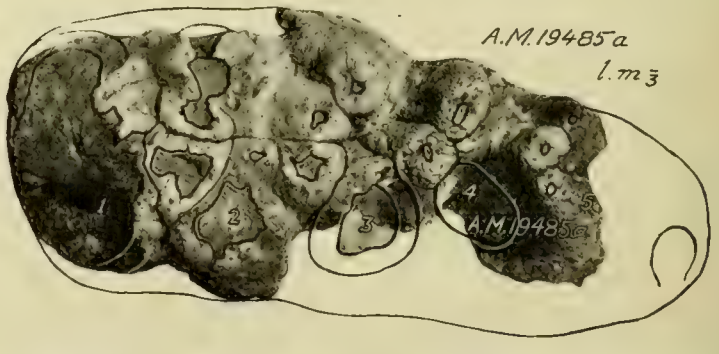


Fig. 632. Referred Superior and Inferior Molars of Synconolophus dhokpathanensis (Amer. Mus. 19485a–d), about one-half natural size, found 500 feet below top of Middle Siwaliks, same level as Hipparion Quarry. The crowns appear to be somewhat simpler than the crown of the Paratype (Amer. Mus. 19720—Fig. 631).

Crown aspect of third left and right superior molars (Amer. Mus. 19485 *d*, *b*).

(Upper) Amer. Mus. 19485*d*. Third left superior molar, $l.M^3$, with internal pair of conelets warped or dislocated posteriorly; external pair normal; four external conelets (1–4). (1) Protoloph restored, showing intermediate conelet; (2) metaloph showing numerous intermediate conelets; (3) tritoloph wanting on internal side; (4) tetartoloph and pentaloph encased in cement.

(Lower) Amer. Mus. 19485*b*. Third right superior molar, $r.M^3$, exhibiting pro-protoloph, also (1–2–3–4) proto-, meta-, trito-, and tetartolophs; external cones in normal position, internal cones and conelets warped or dislocated posteriorly; numerous (5–2) intermediate conelets in the valleys.

Crown aspect of third right and left inferior molars (Amer. Mus. 19485 *c*, *a*).

(Upper) Amer. Mus. 19485*c*. Third right inferior molar, $r.M_3$. Observe (1) worn protolophid, (2) metalophid composed of four main conelets and postero-intermediate trefoil conelet, the three external conelets arched or dislocated posteriorly, (3) tritolophid composed of four main conelets, (4) tetartolophid composed of three main conelets, (5) pentalophid of two main conelets; (5) valleys choked with cement.

(Lower) Amer. Mus. 19485*a*. Third left inferior molar, $l.M_3$. Main internal conelets in normal position; five external conelets (1–2–3–4–5) warped or dislocated. The warping or dislocation of the *external* conelets reverses that of the superior molars, in which the internal conelets are displaced.

Synconolophus propathanensis Osborn, 1929

Figures 415A and 633

Dhok Pathan horizon, 500 feet below top of Middle Siwaliks (=*Hipparion* quarry level), Middle Pliocene, three miles east of Dhok Pathan, India, regarded by Pilgrim as subsequent to Pikermi, Eppelsheim, etc.

The type mandible of this species (Amer. Mus. 19487), originally (Osborn, 1929.797, p. 12) thought to be referable to the genus *Serridentinus*, proved to belong to the genus *Synconolophus*; as the specific name *propathanensis* indicates, it is more primitive than the related species *Synconolophus dhokpathanensis* (cf. Fig. 623).

Synconolophus propathanensis Osborn, 1929. "New Eurasiatic and American Proboscideans, "Amer. Mus. Novitates, No. 393, Dec. 24, 1929, pp. 12, 13.

Type.—Amer. Mus. 19487. A large and finely preserved tuskless lower jaw containing both pairs of inferior grinders, M_2-M_3:

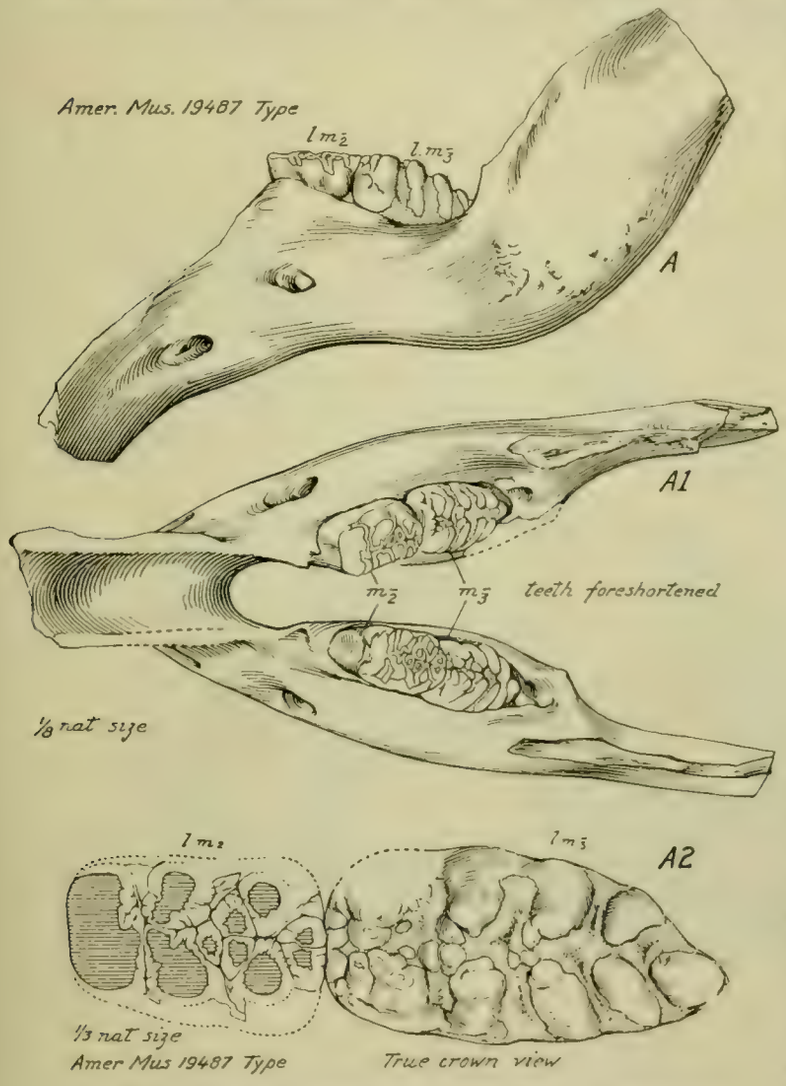


Fig. 633. Type of *Synconolophus propathanensis* Osborn (Amer. Mus. 19187), Dhok Pathan horizon, Middle Siwaliks, India. Compare figure 415A.

A, A1, Left lateral and crown views of mandible. One-eighth natural size.

A2, Crown view of left inferior molars. One-third natural size.

"Mastodon jaws. Middle Siwaliks. Same level as Quarry 1. 3 miles east of Dhok Pathan. Brown, 1922. [Field] No. 46." Middle Pliocene.

Horizon and Locality.—Three miles east of Dhok Pathan, India. Middle Pliocene. Type Figure.—*Op. cit.*, Osborn, 1929.797, fig. 13, p. 13.

This superb specimen (Fig. 633) is referred to the genus *Synconolophus* as the type of a new and very aberrant species *propathanensis*, named after the horizon in which it occurs. It is referred to this genus because of the highly characteristic prolonged, deflected, trough-shaped superior aspect of the symphysis (length 250 mm.), at the extremity of which is a large empty single alveolus that may have contained a pair of slightly upturned, flattened lower incisive tusks (unfortunately missing in this specimen) without bony septum. A second distinctive character is the very large foramen opposite the symphysis on either side, for the vascular supply of the fleshy lower lip, also another large foramen beneath M_2.

The type grinders (Fig. 633) resemble those of *Synconolophus dhokpathanensis* ref. (Figs. 622, 632) in cone and conule compression but differ in the lesser alternation of the main cones. The measurements are as follows:

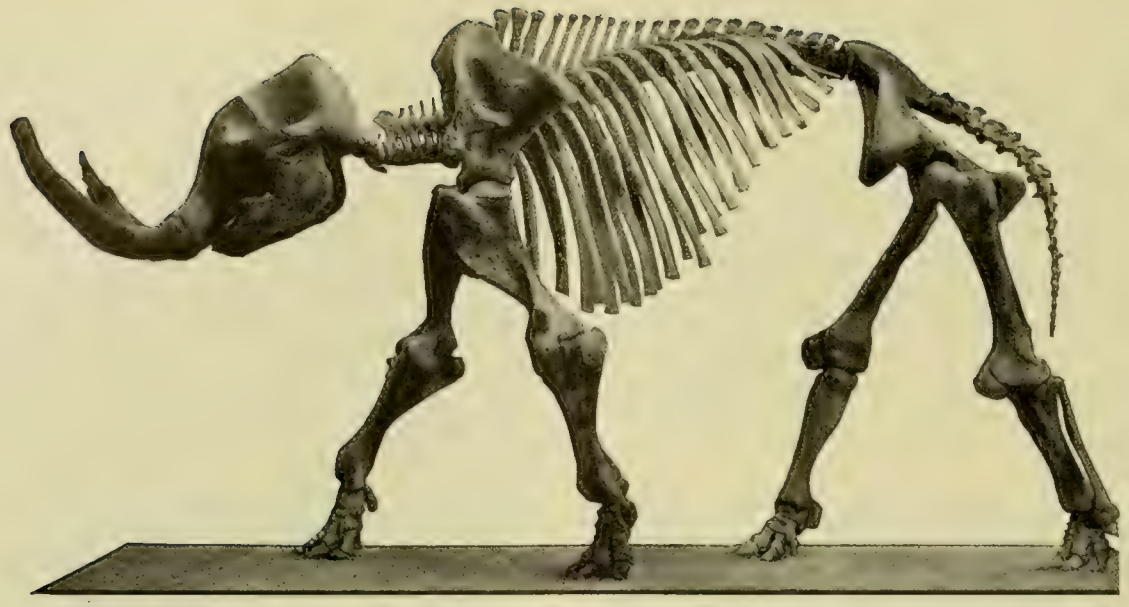
Length of jaw, condyle to end of symphysis, estimated	900 mm.
Length of symphysis on the median line	250
Depth of jaw below M_3	133
Terminal width of symphyseal trough	137
Space occupied by grinders, M_2-M_3	274
Length of second inferior molar, r.M_2	106
Width of same	65
Length of third inferior molar, l.M_3	168
Maximum width of same at tritolophid	76
Height of tritolophid, of M_3	60e

Ridge-crest formula:

M_2 with 3½ ridge-crests, 4 conelets on each crest,
M_3 with ½–4–½ ridge-crests, 4 conelets on each crest, external trefoil conelets on protolophid.

Specific Characters.—(1) Ridge-crests compressed, subhypsodont; (2) deeply covered with cement; (3) summit of crown of M_2 wearing into a subptychodont pattern owing to the crowding of the ridge-crest conelets and (?)conules into the valleys between the main cones; (4) main cones less *alternate* than in *Anancus* and *Stegomastodon*, with two median conelets crowding anteriorly into the valleys; (5) M_2 with 3½ ridge-crests, M_3 with ½–4–½ ridge-crests; (6) height of tritolophid of M_3 60e mm.; (7) the subptychoid pattern is best seen in the partly worn crown summit of M_3 which exhibits on the tritolophid and rudimentary tetartolophid a group of seven closely compressed conelets with crenulate borders; were it not for the directly opposite condition of the outer conelets, this grinder might readily be mistaken for a typical *Anancus*.

Symphysis.—The broad, trough-shaped rostrum resembles that of *Anancus perimensis* (see Fig. 610) and indicates a large, fleshy lower lip for the prehension of herbage.



Mounted Skeleton of Stegomastodon arizonæ Gidley

Fig. 634. Photographic reproduction of type skeleton as mounted in the United States National Museum (Nat. Mus. 10707), one-thirtieth natural size, under the direction of J. W. Gidley. Compare Gidley, 1926, Pl. xxxiii, also figure 640 of the present Memoir.

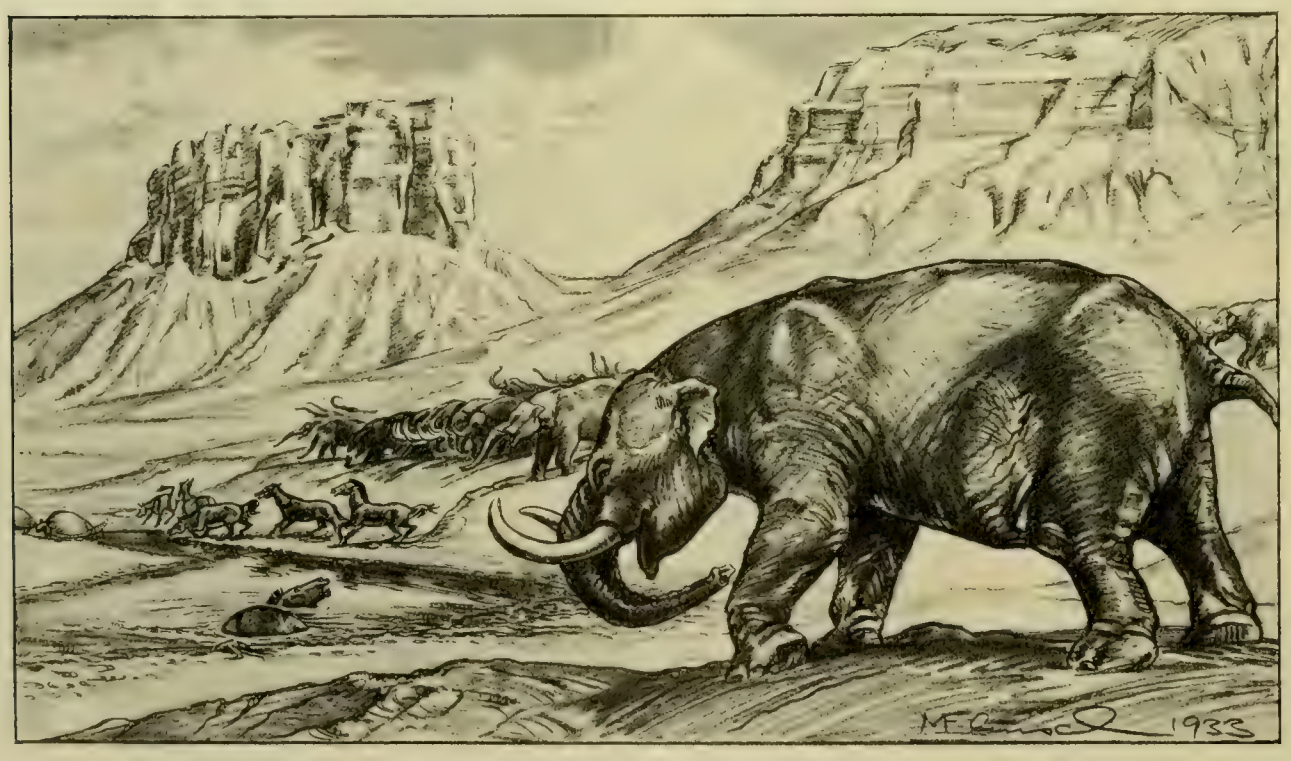


Fig. 635. Stegomastodon arizonæ Gidley, the Curved-tusked Stegomastodont of Arizona
Restoration one-fiftieth natural size, drawn under the direction of the author by Margret Flinsch (1933)

This restoration of a descendant of the classic '*M.*' *mirificus* Leidy is based on the complete mounted skeleton (Figs. 634, 640) in the National Museum. Of uppermost Pliocene age, this American offshoot of the '*Mastodon*' *humboldtii* stock was the companion of *Plesippus*, the horse so near the modern *Equus* that it was first described by Cope as belonging to the existing genus of horses. It seems that other associates were the glyptodont *Glyptotherium arizonæ*. The scene is that of a drying water-hole in which the bogged remains of some of the animals were trampled upon by new entrants maddened by thirst, as in the *Platybelodon grangeri* pool of the Gobi Desert represented in figure 285. See page 680 below for preliminary list of the fauna of this period of desiccation. The same species is represented in figure 648, drawn by Charles R. Knight, under the direction of the author. The life size of this animal is 2648 mm., or 8 ft. 8¼ in.

IV. THE HUMBOLDTINES OF NORTH AMERICA

As explained above on the opening page (p. 617) of this chapter, the North American genus *Stegomastodon*, because of a fundamental resemblance of the grinding teeth to those of '*Mastodon*' *humboldtii* (see Figs. 578–581, Chap. XII) has been removed from the Brevirostrinæ of Eurasia (Fam. Bunomastodontidæ) and placed among the South American mastodonts, of the subfamily Humboldtinæ Osborn, 1934 (Humboldtidæ fam. nov.). This genus includes eight species ranging from Nebraska to Texas, seven of which are described in the present chapter. The description of the new species (*Stegomastodon primitivus*) will be found in the Appendix to the present Volume I. This section, therefore, rightfully belongs in Chapter XII where the '*Mastodon*' *humboldtii* group is treated.

The geographic distribution of the American species of Humboldtinæ is clearly illustrated in figure 590 above. The geologic distribution is still rather uncertain, but according to the progressive characters, the several species may be placed in ascending geologic and phylogenetic order as appears on page 683 below, with the exception of *Stegomastodon priestleyi* and *S. primitivus*.

1. CHARACTERS OF THE GENUS STEGOMASTODON POHLIG

FAMILY: HUMBOLDTIDÆ fam. nov.[1]
SUBFAMILY: HUMBOLDTINÆ Osborn, 1934.

GENUS: **STEGOMASTODON** Pohlig, 1912

Original reference: Bull. Soc. belge Géol., XXVI, Procès-verbaux, October, pp. 187–193, text figs. 1, 2 (Pohlig, 1912).
Genotypic species: *Mastodon mirificus* Leidy, 1858.
Syn: *Rhabdobunus* Hay, 1914.

GENERIC CHARACTERS.—Palate elongate, postnarial opening far back of grinders (*S. texanus*). Skull and jaw abbreviate as in *Anancus;* less abbreviate than in *Pentalophodon;* tusks upturned without enamel; intermediate molars with trilophodont to tetralophodont ridge formulæ instead of pentalophodont, M $2\frac{3\frac{1}{2}}{3\frac{1}{2}}$; molars with quadruple to multiple trefoils completely blocking the valleys; central conules absent; inferior ridge-crests *proverted* as in inferior ridge-crests of *Anancus*, *Pentalophodon*, and *Synconolophus;* crowns of molar teeth ptychodont, labyrinthodont, subhypsodont; posterior molars with progressive ridge formula: M $3\frac{4\frac{1}{2}\text{-}5\frac{1}{2}\text{-}6\text{-}6\frac{1}{2}\text{-}7\frac{1}{2}}{4\frac{1}{2}\text{-}5\frac{1}{2}\text{-}6\text{-}6\frac{1}{2}\text{-}7\frac{1}{2}}$. Mandibular rostrum progressively abbreviated (Fig. 636), *Stegomastodon successor* to *S. texanus* (cf. Fig. 553).

The successive explorations of the late James W. Gidley in Texas have revealed the most remarkable phyletic ascending series to the very summit of the Pliocene *Plesippus simplicidens* life zone, while *Stegomastodon aftonia* carries us into the Lower to Middle Pleistocene life zone of *Archidiskodon meridionalis nebrascensis*.

STEGOMASTODON.—Pohlig originally selected Leidy's *Mastodon mirificus* as the genotypic species of the new genus *Stegomastodon*, characterizing it (1912, pp. 192, 193) as follows:

> . . . "et cette position importante des Mastodontes américains, . . est encore accentuée par un autre caractère que par la présence de quatre défenses sans émail, caractère qui n'avait pas été reconnu jusqu'ici et que je signale aujourd'hui: dans des Mastodontes américains, *il y avait déjà occasionnellement du cément sur l'émail au fond des tranchées entre les crêtes transversales postérieures des dernières molaires;* c'est prouvé, notamment, par une superbe dent de *Stegomastodon* cf. *mirificum* Leidy (prototype de *Stegomastodon* Pohlig), qui fut vendue par Krantz en 1902. Jusqu'à ce jour, on ne connaissait pas encore la présence de *cément* sur l'émail des molaires dans une espèce du genre *Mastodon;* et on croyait que l'origine de sa formation n'apparaissait que dans les Stégodontes."

[1]For definition of the Humboldtidæ fam. nov. and of the Humboldtinæ Osborn, 1934, see Appendix to the present Volume I.

Although Pohlig was in error in believing that the presence of cement in the transverse valleys distinguished this genus from all other mastodonts, we are confident that the name *Stegomastodon* will stand, as designating the brevirostral mastodonts in which chœrodonty arises by the corrugation and final labyrinthine foldings of the enamel.

Rhabdobunus.—In 1914, Hay also selected *Mastodon mirificus* Leidy as the genotypic species of the new genus *Rhabdobunus*, as follows:

(Hay, 1914, p. 59): The mastodon remains are described on a future page as *Rhabdobunus mirificus*. ... [*Op. cit.*, p. 373]: Genus *Rhabdobunus* Hay. Elephantine animals whose upper tusks were probably without an enamel band; inferior tusks wanting and the lower jaw much shortened. Hindermost molars of the type species with cross-crests composed each of two blunt cones whose enamel is strongly fluted; transverse valleys blocked by contact of the principal cones.

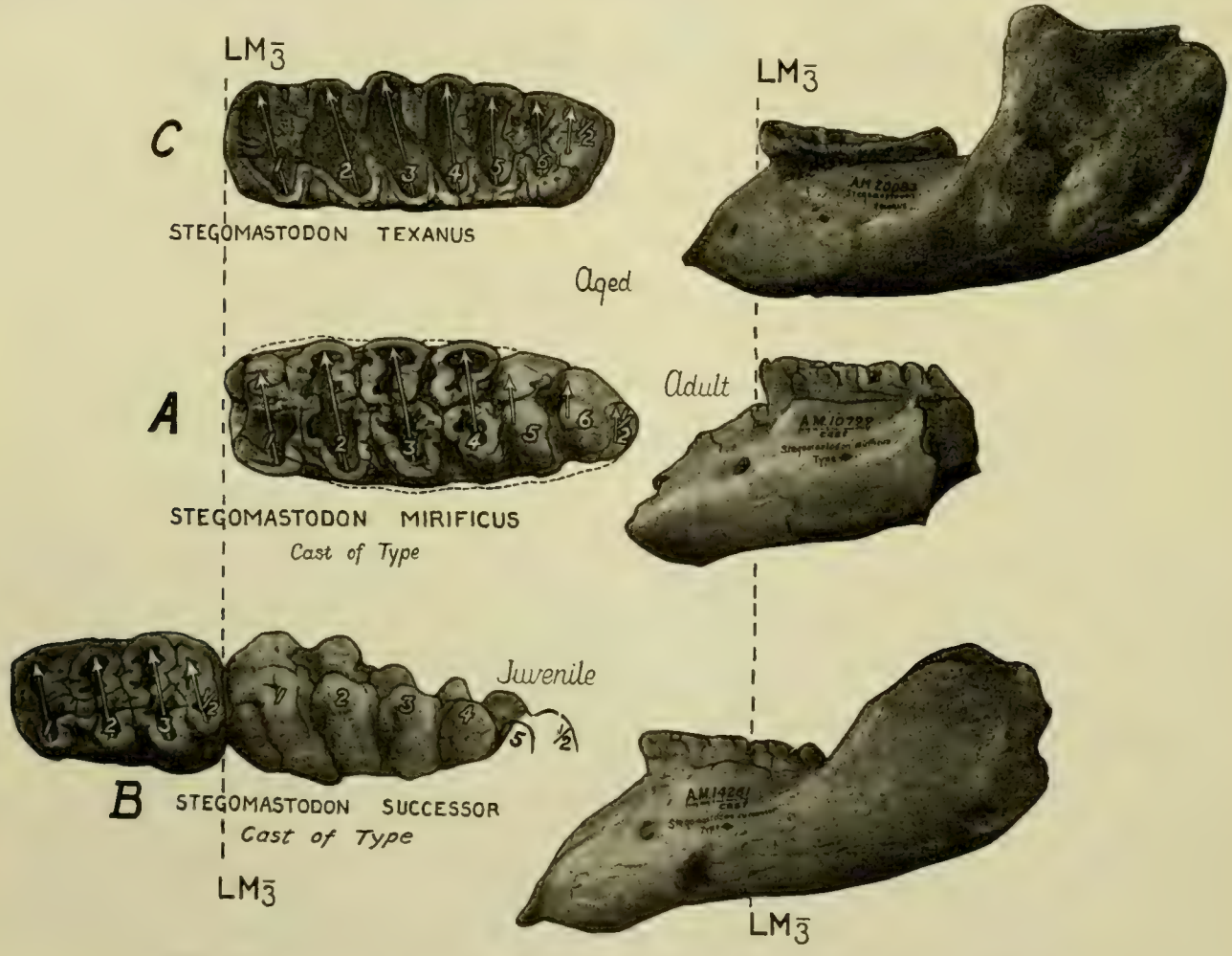


Fig. 636. Stegomastodon Mandibular Abbreviation (B, A, C). Ridge-crest Internal Proversion

Left mandibular rami of *Stegomastodon successor* type (cast Amer. Mus. 14281); *S. mirificus* type (cast Amer. Mus. 10799), and *S. texanus* ref. (Amer. Mus. 20083); progressive abbreviation of rostrum in front of l.M_3. Observe strong *internal proversion* of the 5½+ inferior ridge-crests, as indicated by the white arrows. Compare figure 553 of Chapter XII.

Generic Distinctions, Osborn, 1924.—In the course of the present revision of the Proboscidea, Osborn at first regarded the *Mastodon mirificus* of Leidy as belonging to the genus *Anancus* Aymard, to which it is related by many fundamental Brevirostrine characters of the molar teeth, but the discovery of a nearly complete maxillary and mandibular dentition, in the explorations by J. W. Gidley during the years 1899–1901 in the Blanco formation,

revealed a trilophodont ridge formula of the intermediate molars, M 1, M 2, entirely distinct from that of either *Anancus* or *Pentalophodon*, namely:

$$\text{Dp } 4\tfrac{3}{3} \quad \text{M } 1\ \tfrac{3\frac{1}{2}}{3\frac{1}{2}} \quad \text{M } 2\ \tfrac{3\frac{1}{2}}{3\frac{1}{2}} \quad \text{M } 3\ \tfrac{4\frac{1}{2}\text{-}5\frac{1}{2}\text{-}5\frac{1}{2}+}{4\frac{1}{2}\text{-}5\frac{1}{2}\text{-}6+}.$$

Whereas the prevailing ridge formula of the intermediate molars in *Anancus* is: Dp 4 (?) M $2\frac{1}{4}$, and in *Pentalophodon*, Dp 4 (?) M $2\frac{2}{3}$; in *Stegomastodon* it is, Dp 4 (?) M $2\ \frac{3\frac{1}{2}}{3\frac{1}{2}}$; the relative trilophodont simplicity and conservatism of the intermediate molars in *Stegomastodon* is compensated for by the progressive, labyrinthine, and ptychodont enamel folding of the third molars, M 3. Another generic character of significance is the short, massive, upcurved, outcurved superior tusks of *Stegomastodon*, in contrast to the long, straight tusks to which Aymard applied the name *Anancus*.

2. CHARACTERS OF THE SPECIES STEGOMASTODON CHAPMANI HAYS, 1834-1843, AND OF S. MIRIFICUS LEIDY, 1858

Stegomastodon chapmani Hays, 1834, 1843

Figure 637

From an unrecorded locality in the United States; type lost or misplaced.

This, the first Humboldtine described from North America, was compared by Hays (1834) to *Mastodon arvernensis*. Unfortunately it is not known whether the type specimen was found in the eastern or western part of the United States; it undoubtedly belongs to the Humboldtine phylum, and it is extremely interesting to note that Hays himself observed its resemblance to teeth from northern Italy which we now know belong to *Anancus arvernensis*. Doctor Hays dedicated it to Doctor Chapman in 1834, but the name *Mastodon Chapmani* was not published until 1843 (Hays, 1843.2, p. 270) in the Proceedings of the American Philosophical Society.

Fig. 3. *Fig. 4.*

THE FIRST STEGOMASTODON DESCRIBED FROM NORTH AMERICA

Fig. 637. Type of *Mastodon Chapmani* Hays, 1834, Pl. XXII, figs. 3 and 4, one-fourth natural size. Locality not known. Cabinet of Amer. Phil. Soc., Philadelphia. Regarded by Leidy as "comprising three divisions, of the last upper molar of the right side," r.M^3.

Mastodon Chapmani Hays, 1834, 1843. "Descriptions of the Specimens of Inferior Maxillary Bones of Mastodons in the Cabinet of the American Philosophical Society, with Remarks on the genus Tetracaulodon (Godman), etc." Trans. Amer. Phil. Soc., N.S., 1834, Vol. IV, p. 338, and [Motion of Dr. Hays to have casts made of tooth of *Mastodon Chapmani*], Proc. Amer. Phil. Soc., 1843, Vol. II, p. 270. TYPE.—(Explanation of Pl. XXII, figs. 3, 4, Hays, 1834): "Two views of a molar tooth, upper jaw, of a Mastodon, in the cabinet of the American Philosophical Society." (Leidy, 1869, p. 248): "Apparently it consists of the fore part, comprising three divisions, of the last upper molar of the right side. It is much worn, and the embracing enamel of the first division of the crown, together with the greater part of the outer lobe of the second division, are broken away." HORIZON AND LOCALITY.—Not mentioned. (Leidy, 1869, p. 248): "Nothing is known in regard to the locality." TYPE FIGURE.—Hays, 1834, Pl. XXII, figs. 3 and 4.

TYPE DESCRIPTION.—(Hays, 1834, p. 338): "This tooth appears to differ from any hitherto described. It resembles the teeth represented in Cuvier, (Ossemens Fossiles, Plate IV. fig. 1, 3, 4, and 6, Divers Mastodontes) in the enamel being crenulated; but it differs from them in the arrangement of the enamel. It is probably an undescribed species, and we propose to dedicate it to our estimable friend, the distinguished professor of the institutes and practice of medicine in the University of Pennsylvania, and Vice-President of this Society, Dr. Chapman."

Osborn, 1924: This type was rightly compared by Hays with Cuvier's figures of similar teeth apparently belonging to '*M.*' *arvernensis* from northern Italy (Cuvier, Ossemens Fossiles, Plate IV, Divers Mastodontes) distinguished by the *alternation of the inner and outer cones* and the extreme brachyodonty. Leidy recognized *M. chapmani* in his type description of *M. mirificus* (Leidy, 1858.2, p. 10); he correctly stated that it more nearly resembled *M. humboldtii*. Leidy observed that *M. chapmani* of Hays and his own *M. mirificus* represented related forms.

Osborn, 1926: Without examination of the type, it is not possible to make a proper comparison, but *M. chapmani* appears to be less hypsodont than Leidy's type of *M. mirificus*.

Stegomastodon mirificus Leidy, 1858

Figures 553, 636, 638, and 642

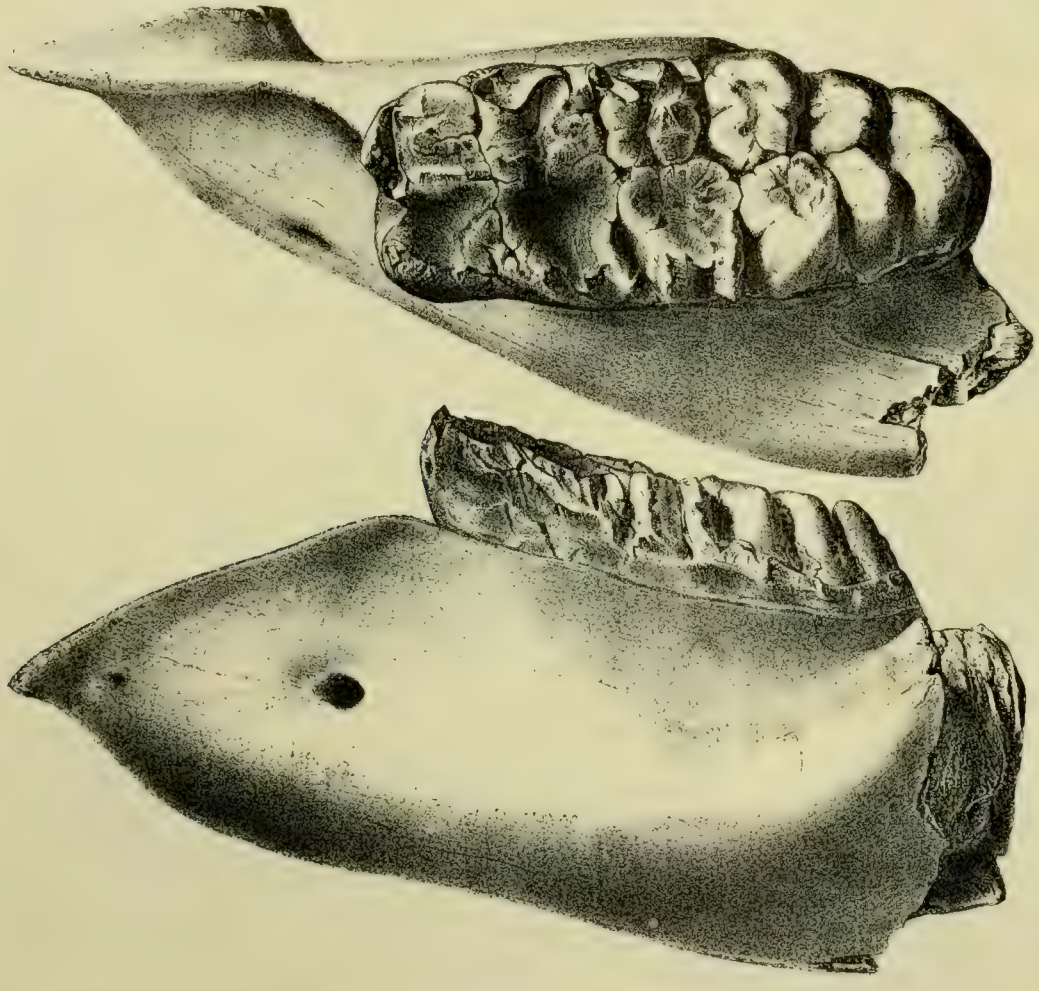
Of Upper Pliocene(?) age,[1] "Loup Fork of Platte River," Nebraska, *fide* Leidy, Osborn. Probably near Seneca, Thomas County, Nebraska (*fide* Hay, 1924, p. 100).

This is the second Humboldtine described from North America and is apparently distinguished by the presence of double trefoils on the anterior ridge-crests (see figure 638 after Leidy). This species was founded on a lower jaw discovered by F. V. Hayden on the "Loup Fork of Platte River," Nebraska, and is probably of

[1][According to the field determinations of the University of Nebraska Expeditions (see Lugn and Schultz, 1934.1, p. 372), this horizon is definitely Lower to Middle Pleistocene, both from geologic and faunal evidence.—Editor.]

Upper Pliocene[1] age, the exact geologic level of the type jaw being uncertain. The jaw was compared by Leidy with '*M' sivalensis*. The specific name *mirificus* doubtless refers to the elaborate foldings of the enamel which are imperfectly represented in Leidy's type figure (Fig. 638); there are apparently two trefoils on the inner and two on the outer lobes (cones), making four in all; the alternation of the inner and outer lobes is somewhat less marked than in certain species of *Anancus* and *Pentalophodon*.

Mastodon mirificus Leidy, 1858.2. "Remarks on fossils from Nebraska." [A new species of mastodon and elephant from Nebraska, *Mastodon mirificus*, *Elephas imperator*], Proc. Acad. Nat. Sci. Phila., 1858, Vol. X, p. 10.



Type Jaw of Stegomastodon mirificus

Fig. 638. Left ramus of type jaw of *Mastodon mirificus* Leidy, 1858, after Leidy's original type figure in "The Extinct Mammalian Fauna of Dakota and Nebraska," 1869, Pl. xxv, figs. 1, 2. Original lithograph one-half natural size; present figure one-third natural size. Nat. Mus. 209; cast Amer. Mus. 10799.

Observe slight *internal proversion* of the six ridge-crests.

Mastodon (*Tetralophodon*) *mirificus* Leidy, 1858.4. "Notice of Remains of Extinct Vertebrata, from the Valley of the Niobrara River," . . . Proc. Acad. Nat. Sci. Phila., 1858, Vol. X, p. 28.

Type.—Part of the left jaw containing the third molar, M_3; Nat. Mus. 209, cast Amer. Mus. 10799; the right side of the type jaw is in the Philadelphia Academy collection. Horizon and Locality.—Hayden Expedition of 1857; first attributed to valley of Niobrara River, horizon F of Hayden; the type jaw is probably from the Loup Fork of Platte River (cf. Leidy, 1873, p. 330); it is so inscribed in Leidy's hand. Type Figure.—Leidy, 1869, Pl. xxv, figs. 1, 2.

Type Description.—(Leidy, 1858.2, p. 10): "Dr. Leidy directed the attention of the members to some fossils on the table, being part of the collection obtained by Dr. F. V. Hayden, in the valley of the Niobrara river, Nebraska. One of the specimens was the lower jaw of a new species of Mastodon. It belonged to an old individual, as the last molar tooth occupies its functional position and is considerably worn. The jaw indicates a smaller animal than the common Mastodon (*M. Ohioticus.*) The tooth resembles the corresponding one of *M. sivalensis*, or of *M. angustidens*, much more nearly than that of the common Mastodon. The crown has a much greater antero-posterior diameter in relation to its transverse diameter, than in the latter, and it has six transverse rows of tubercles, together with a feeble tarsus. The tubercles are crowded instead of being separated by wide angular valleys as in the common Mastodon. The tooth was compared with that from an unknown locality, characterized by Dr. Hays under the name of *M. Chapmani;* but this more nearly resembles the South American species *M. Humboldti.* In advance of the tooth, there are no traces of an alveolus for the preceding tooth, but a sharp ridge proceeds from the last molar to the anterior extremity of the jaw. Dr. Leidy observed he had never seen the jaw of the common Mastodon in the same condition, as the oldest individuals always presented the fifth alveolus filled up, and not completely obliterated. The species he named *Mastodon mirificus.*"

(Leidy, 1858.4, p. 28): "*Mastodon* (*Tetralophodon*) *mirificus*, Leidy. One of the most interesting discoveries of Dr. Hayden in the pliocene deposit of the valley of the Niobrara, is the greater portion of the lower jaw of a Mastodon, most undoubtedly distinct from that species whose remains are so abundantly found in later deposits in the United States. The specimen belonged to an old individual, as the last molar tooth had protruded and is considerably worn off at its anterior two-thirds; and it indicates a much smaller animal than the *M. ohioticus.* The form of the jaw is like that of the existing Elephant of India. A single tooth, the last molar, occupies each side of it, and resembles the corresponding one

[1]See footnote on page 669.

of *M. angustidens*, of Europe, or of *M. sivalensis*, of the Sivalic Hills, of India. The crown measures nine inches antero-posteriorly, and three and a half inches transversely, and possesses six transverse rows of conical lobes closely crowded. In advance of the sixth molars, preserved in the specimen, no traces of alveoli are left for preceding teeth, but a sharp sigmoid ridge extends to the front of the jaw."

Specific Characters of Type (Leidy, Hay, Osborn).—(1) Six cross-crests with rudimentary talon. (2) Crests one to five composed of two main cones, subdividing into two conelets with indications of reduplicate trefoils, i.e., quadruple trefoils; crest six of two primitive cones, not subdivided. (3) Enamel borders less labyrinthine and complex than in *Stegomastodon chapmani* or *S. arizonæ*. (4) Enamel fluted or ptychoid, especially on the inner half of the outer cones and on the outer two-thirds of the inner cones, thrown into grooves which run from base to summit. (5) Where the tooth is worn down, these folds appear as thick festooned bands of enamel; of these folds there are about six on each cone of the transverse crests. (6) At the base of the whole six ridge-crests is a coat of cement, all ridge-crests probably originally so covered; patches of cement in the valleys of the hinder part of the tooth. (7) Length of lower molar tooth equals 222 mm., greatest width equals 80 mm., breadth-length index equals 36. (8) Osborn (1924) observes double trefoils in the type both on the inner and outer cones of the anterior crests of the protolophid, the metalophid, and the tritolophid; these double trefoils are rudimentary and are less prominent in the tetartolophid; they do not appear in the pentalophid; the hexalophid consists of only two main cones, hardly more than a half ridge-crest, when viewed from above.

Primitive Phylogenetic Position of Type (Osborn, 1924).—The type of '*M.*' *mirificus* (Fig. 638) is *primitive* as compared with the types of other and far more progressive species recently discovered in America. It will be observed that, while seen from the side, *six* ridge-crests may be counted, as seen from above the hexalophid is composed of two cones only; it has not yet subdivided into four conelets as in the five anterior crests, consequently the ridge formula is $M\,3\,\frac{\cdots}{5\frac{1}{2}+}$. These type teeth, therefore, are in a much earlier stage of evolution than those of *Stegomastodon texanus* from the Upper Pliocene Blanco or of *S. arizonæ* from the Upper Pliocene San Pedro, and far less progressive than those of *S. aftoniæ* of the Lower Pleistocene of Iowa (Aftonian?)[1], in which the formula is $M\,3^{7\frac{1}{2}}$.

Geologic Age of Type.—(Hay, 1914, p. 374): "*Rhabdobunus mirificus* (Leidy). This species was founded on the greater part of a lower jaw which was discovered by F. V. Hayden within the present state of Nebraska. . . . On the jaw is printed by Leidy's hand 'Loup Fork of Platte River.' Of the type jaw the left ramus was figured in Leidy's work 'The Extinct Mammalian Fauna of Dakota and Nebraska,' plate xxv, figures 1 and 2. This part of the jaw is now in the collection of the National Museum. The right side of it is in the Philadelphia Academy's collection. Leidy's figure shows that the jaw has suffered slight injuries since the illustration was made. It has been supposed that this species belonged to the Pliocene or even to the Miocene. However, in Leidy's work last cited, on page 251, it is stated that Hayden had observed mastodon remains, probably belonging to this species, in association with those of Hipparion and Elephas, at the head of the Loup Fork branch of Platte river, between that point and Niobrara river, and in the course of the latter. This seems to indicate the presence of Pleistocene deposits in that region; and, certainly *Elephas* [*Parelephas*] *columbi* is there found."

Osborn (1924) does not accept the conclusion of Hay; for reasons stated above and below, Osborn regards the type of '*M.*' *mirificus* as of Upper Pliocene age.[2]

3. RECENTLY DISCOVERED HUMBOLDTINES OF THE SOUTHWEST, STEGOMASTODON SUCCESSOR, S. TEXANUS, AND S. ARIZONÆ

Stegomastodon successor Cope, 1892

Figures 553, 636, 641, 643, and 644

Upper Pliocene, Blanco formation, Texas.

Stegomastodon successor is the first Humboltine to be described from the Blanco formation. The five and a half crested (+5½) third inferior molar (Fig. 641) should be compared with the six plus (6+) crested third inferior molar of *S. mirificus* (Figs. 638, 636) and with the much more complex six and a half plus crested molar of *S. texanus* (Fig. 642 B2).

This species proves to be more primitive than *Mastodon* [=*Stegomastodon*] *mirificus* of Leidy; the type has had a checkered history. In 1892 Cope based it upon a lower jaw (Fig. 641) and upper tusk from the Blanco beds of Texas and very accurately described (1892.4, p. 227) and figured it (1893.1); he erroneously designated it, however, as "nearest to the *Mastodon andium*." Previous to this Cope had described as *Dibelodon tropicus* a tooth actually related to *Mastodon andium* or *M. humboldtii*. Accordingly in 1893 Cope (1893.1, p. 63) wrote: "On this supposition I suspected the animal to represent a species distinct from the *M. tropicus* and named it *M. successor*, as above cited. This name [i.e., *Mastodon successor*] is now withdrawn."

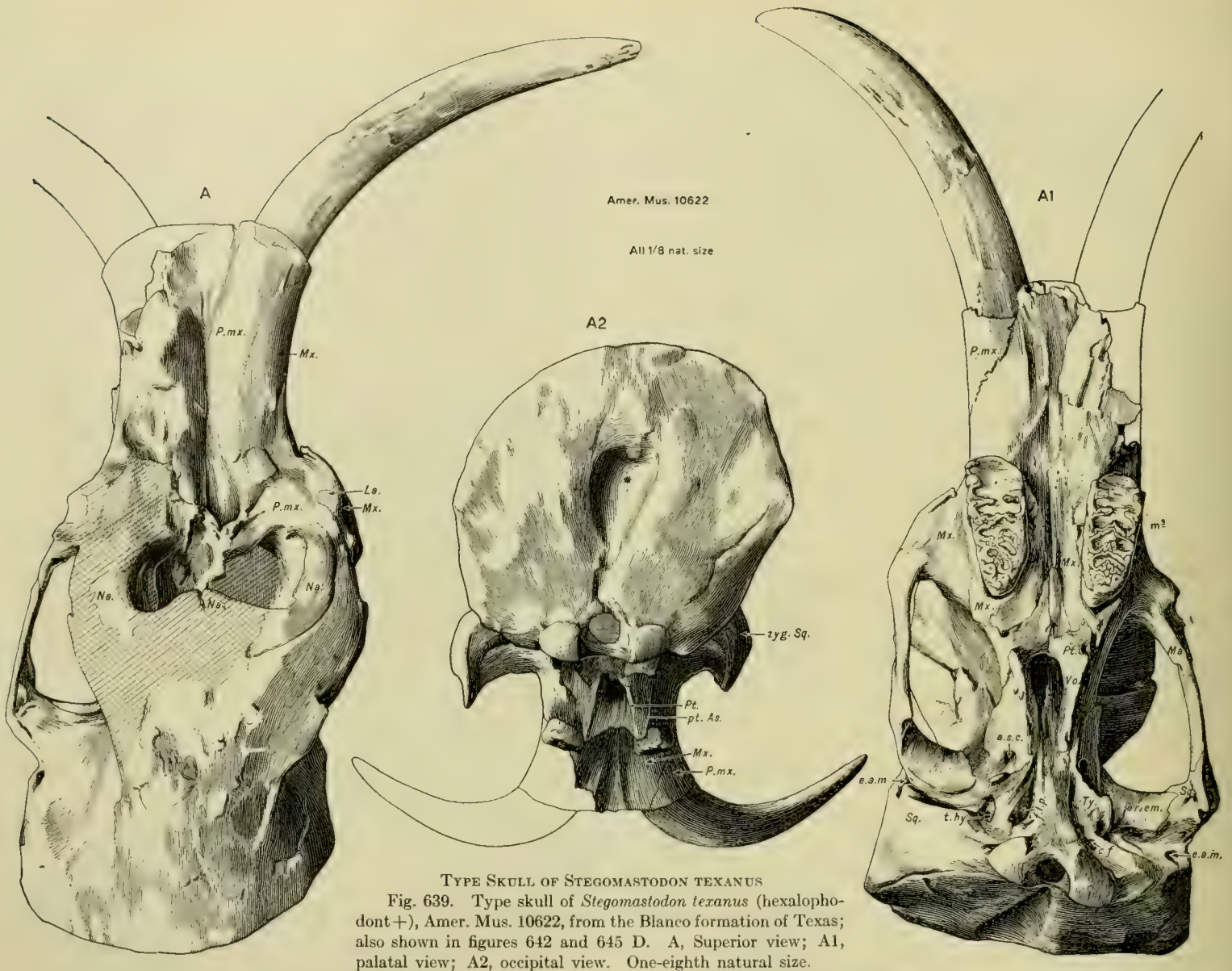
Thus for thirty-one years the specific name *Mastodon successor* Cope has been erroneously listed as a synonym of *Dibelodon tropicus* Cope. Osborn now revives *Mastodon successor* of the Blanco as a well-recognized and distinct species of the genus *Stegomastodon*.

The type of *Mastodon* [=*Stegomastodon*] *successor* Cope (Fig. 641) appears to be more primitive than the type of *M.* [=*Stegomastodon*] *mirificus* Leidy (Fig. 638), because the rostrum of the jaw is more elongate; the third inferior molars have five and a half plus ridge-crests, namely, $M\,3\,\frac{\cdots}{+5\frac{1}{2}}$, but the rudimentary hexalophid in M_3 is far less developed than the hexalophid in *S. mirificus*. *S. successor*, therefore, appears to be one of the most primitive species of *Stegomastodon* thus far discovered in America, unless the *Mastodon* [=*Stegomastodon*] *chapmani* Hays proves to be still more primitive.

Mastodon successor Cope, 1892. "A Contribution to a Knowledge of the Fauna of the Blanco Beds of Texas." Proc. Acad.

[1][Dr. A. L. Lugn and Mr. C. Bertrand Schultz have carefully considered the geological age of the deposit in which the type specimens of *Stegomastodon aftoniæ* were found and are led to believe that it is of Yarmouth rather than of Aftonian age, that is, Lower to Middle Pleistocene.—Editor.]

[2]See footnote on page 669.



TYPE SKULL OF STEGOMASTODON TEXANUS

Fig. 639. Type skull of *Stegomastodon texanus* (hexalophodont+), Amer. Mus. 10622, from the Blanco formation of Texas; also shown in figures 642 and 645 D. A, Superior view; A1, palatal view; A2, occipital view. One-eighth natural size.

This type is the first skull found in North America of this interesting Humboldtine phylum.

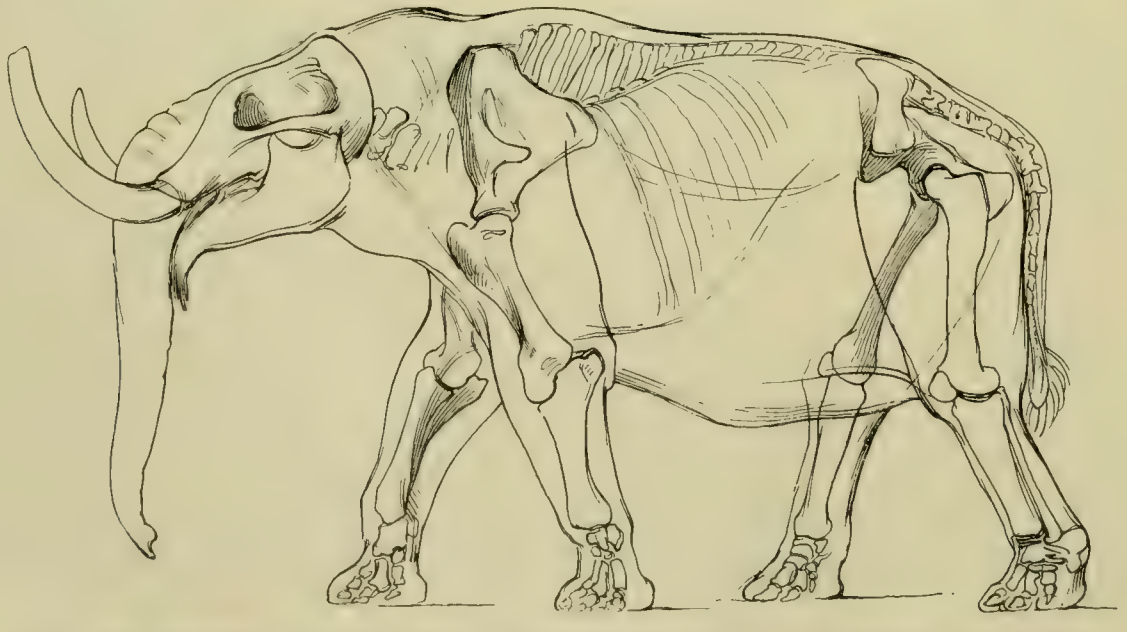
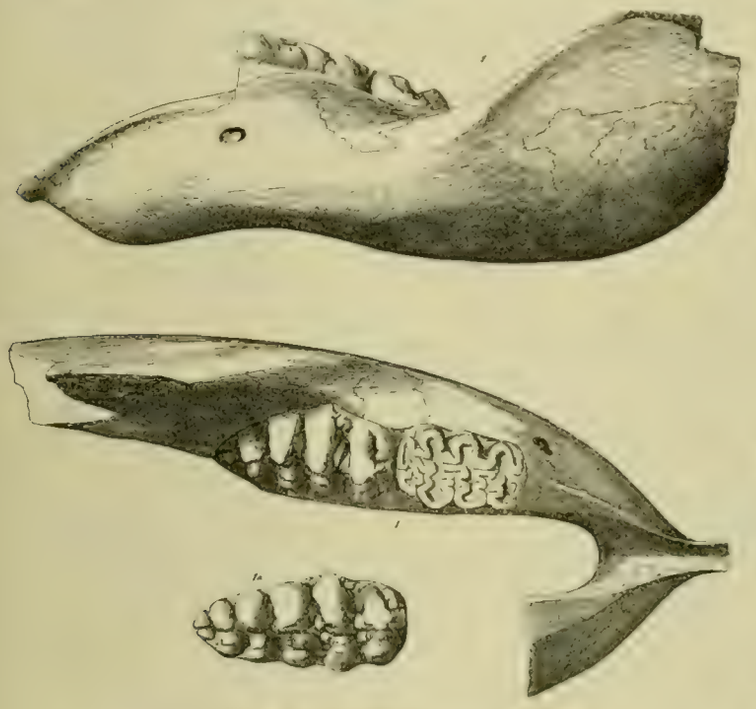


Fig. 640. Restoration and sketch by Charles R. Knight of mounted skeleton of *Stegomastodon arizonæ* Gidley (Nat. Mus. 10707). One-thirtieth natural size. Compare figure 634.

Nat. Sci. Phila., Vol. XLIV, pp. 227, 228. TYPE.—(*Op. cit.*, p. 227): "The most complete specimen is represented by both rami of the lower jaw with symphysis complete, but lacking angles and condyles; accompanied by a tusk of the upper jaw. The latter is without enamel band." HORIZON AND LOCALITY.—Collected by Professor W. F. Cummins, Blanco beds, Texas. Original in Texas Geological Survey Collection, Austin, Texas; cast Amer. Mus. 14281. Upper Pliocene (cf. Osborn, 1918.473, p. 34) the *Glyptotherium-Pliohippus simplicidens* zone. TYPE FIGURE.—Cope, 1893.1 (4th Ann. Rept. Geol. Surv., Texas, for 1892), Pl. XVI, figs. 1, 1*a*, and Pl. XVII, fig. 1. In these plate figures the legends erroneously read "*Dibelodon tropicus*," the species founded by Cope upon von Meyer's type.



TYPE JAW OF STEGOMASTODON SUCCESSOR

Fig. 641. Type of *Mastodon successor* Cope, 1892. Original figure of type jaw and left M_{2-3}. After Cope, 1893.1, Pl. XVI, figs. 1, 1*a*, and Pl. XVII, fig. 1. One-sixth natural size. Cummins Collection, Blanco beds, Texas; in the Texas Geological Survey Collection. Cast Amer. Mus. 14281. Figured by Cope as *Dibelodon tropicus*; referred by the present writer to *Stegomastodon successor*.

(Cope, 1892.4, p. 227): "The most complete specimen is represented by both rami of the lower jaw with symphysis complete, but lacking angles and condyles; accompanied by a tusk of the upper jaw. The latter is without enamel band."

TYPE DESCRIPTION.—(Compare Cope, *op. cit.*, 1892.4, pp. 227, 228) (1) The tusk of the upper jaw is without enamel band. (2) "The second true molars are in place, showing their patterns, and the third molars have only three crests protruded. Besides the subsidiary tubercles which form the trefoils of the inner side of the molars there are a few other tubercles closing the valleys. The second true molars have a narrow fourth cross-crest. Measurements: Length of left ramus preserved 2.55 feet; length from anterior base of coronoid process to apex of snout 1.55 feet; length of second true molar .45 feet; width between second molars .35 feet; total width of rami at middle of M.3–1.4 feet; width of crown of M.3 at front crest .35 feet; diameter of tusk near middle .625 feet. This species is nearest to the *Mastodon andium* Laurill., but that species, according to Burmeister, has an elongate symphysis, although without tusks."

SPECIFIC CHARACTERS (OSBORN, 1924).—(1) Second inferior molar, M_2, length 114 mm., width 78 mm., index 68, with three and a half ridge-crests, (?) single internal trefoils. (2) Third inferior molar, M_3, length 191+ mm., width 80e mm., index 42e, ridge-crests M $3\ \frac{1}{4\text{-}5\text{-}4\frac{1}{2}}$; double trefoils on proto-, meta-, trito-, and tetartolophids; pentalophid consisting of two half-cones without trefoils; hexalophid consisting of two primitive conelets. These characters, produced from the type cast (Amer. Mus. 14281) in which more than half of M_3 is still buried in the jaw, demonstrate that in respect to dental complication, i.e., cones and trefoils, the type of *Stegomastodon successor* is more primitive than Leidy's type of '*Mastodon*' *mirificus* which exhibits quadruple trefoils on the proto-, meta-, trito-, and tetartolophids; *S. successor* appears to be more progressive than the type of '*M.*' *mirificus* in the vertical hypsodonty of the ridge-crests which measure 70 mm. Consequently Cope's type of *M. successor* belongs to the genus *Stegomastodon*, as refigured in figure 643C, C1, C2. It is seen to be most nearly related to *Stegomastodon mirificus* (pentalophodont+).

Stegomastodon texanus Osborn, 1924

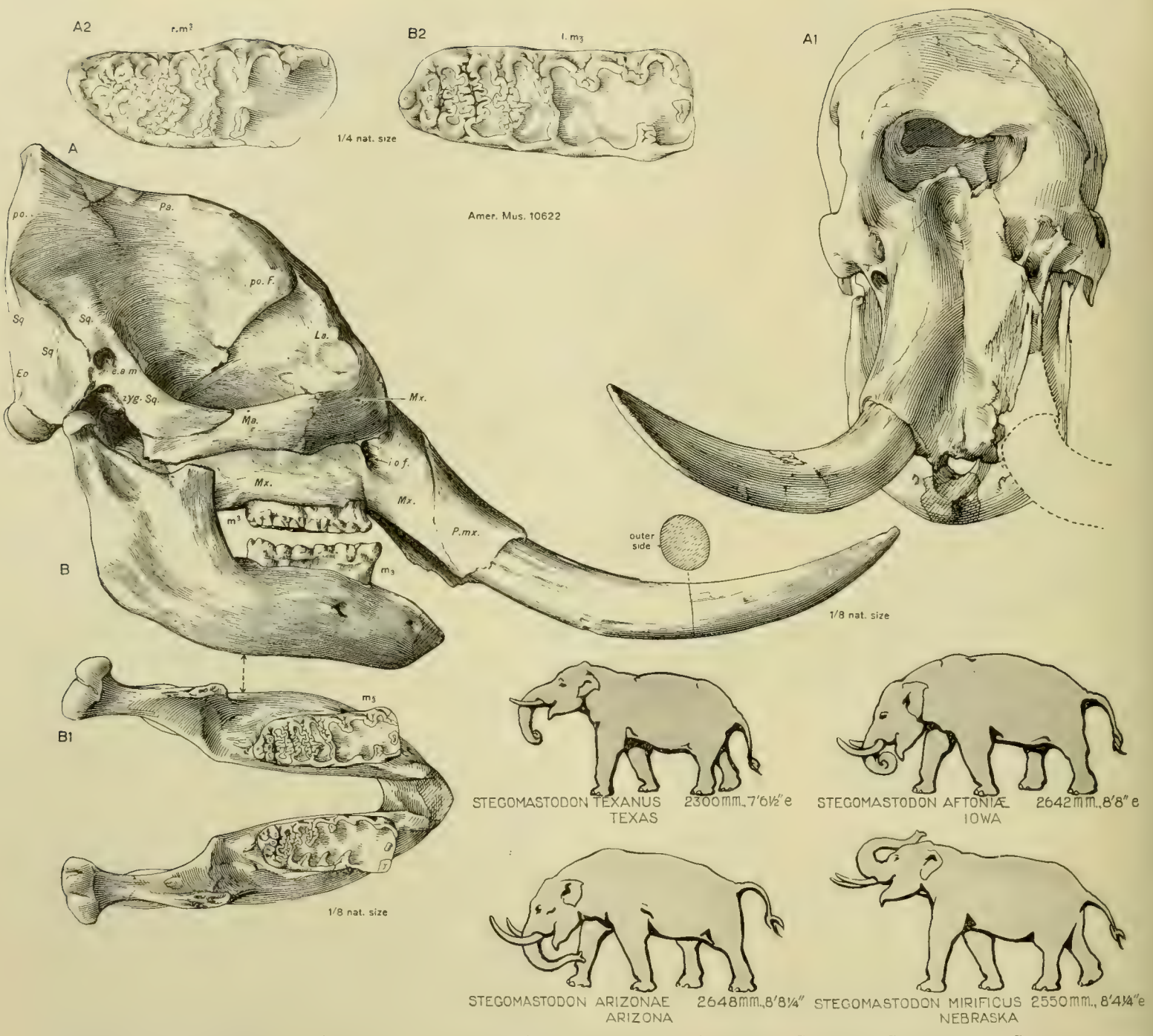
Figures 553, 636, 639, 642-645

Upper Pliocene, Blanco formation, Llano Estacado, Texas.

The third inferior molar, M_3, in the types of *Stegomastodon mirificus* and of *S. successor* is pentalophodont+; in the present species it is hexalophodont+, in fact, a heptalophid and rudiment of an octalophid are observed. Consequently *S. texanus* is much more progressive than *S. mirificus* and certainly more recent in geologic time.

The type of this species is an aged female skull (Amer. Mus. 10622), originally referred by Gidley and by Osborn to the *Mastodon mirificus* of Leidy but later found to belong to a distinct and much more progressive stage. The paratype is a less aged adult jaw (Amer. Mus. 10623). The grinders of *Stegomastodon texanus* are much more hypsodont and much more ptychodont, or chœrodont, than those of the type of *M. mirificus*. Whereas both *Mastodon* [=*Stegomastodon*] *mirificus and M.* [=*Stegomastodon*] *successor* have five and a half perfect ridge-crests, the type and paratype of *S. texanus* have six and a half ridge-crests, that is, they are *hexalophodont+*, and thus are much more progressive. We observe that in *S. texanus* (Fig. 642 B2) the tetartolophid, pentalophid, and hexalophid have highly ptychoid enamel crests; the heptalophid consists of three cones, the octalophid of two low cones.

Stegomastodon texanus Osborn, 1924. "Additional Generic and Specific Stages in the Evolution of the Proboscidea." Amer. Mus. Novitates, No. 154, December 24, 1924, p. 3. (Osborn, 1924.634). TYPE.—Aged female skull and jaws (Amer. Mus. 10622). PARATYPE.—A less aged lower jaw (Amer. Mus. 10623). HORIZON AND LOCALITY.—Upper Pliocene, Blanco formation, Llano Estacado, Texas. TYPE FIGURE.—Figures 639, 642, 644A, A1, 645D of the present Memoir. PARATYPE FIGURE.—Osborn 1924.634, fig. 2A, A1; figures 643A, A1, and 644 B, B1, of the present Memoir.



TYPE SKULL AND DENTITION OF STEGOMASTODON TEXANUS. ALSO RESTORATIONS OF S. MIRIFICUS, S. ARIZONÆ, S. TEXANUS, AND S. AFTONIÆ

Fig. 642. Type female(?) skull and dentition of *Stegomastodon texanus* (hexalophodont+), Amer. Mus. 10622, from the Blanco formation of Texas, Upper Pliocene; collected by J. W. Gidley, American Museum Expedition of 1900. Also shown in figures 639 and 645 D.

A1, Front view of type skull. One-eighth natural size.

A2, Type third right superior molar. One-fourth natural size.

A, B, Right lateral view of type skull and jaw. One-eighth natural size.

B1, Superior view of type lower jaw. One-eighth natural size.

B2, Type third left inferior molar. One-fourth natural size.

Observe that in this ascending mutation of *Stegomastodon texanus* as in the paratype jaw (Amer. Mus. 10623—Fig. 643 A, A1), M_3 is six and a half plus crested, or hexalophodont+ (i.e., rudimentary heptalophid and octalophid), whereas in Leidy's type of '*M.*' *mirificus*, M_3 is five and a half plus (6+) crested or pentalophodont + (i.e., five complete crests, a half crest, and a feeble talonid), and in Cope's type of '*M.*' *successor*, M_3 is plus five and a half crested or pentalophodont + (i.e., a half crest, five complete crests, and a half crest).

TYPE AND PARATYPE.—The type is an aged female skull and jaws collected by J. W. Gidley on the American Museum Expedition of 1900, in the Blanco formation of Texas. The type is beautifully illustrated in the following figures of this Memoir, namely, figures 639, 642, 644A, A1, 645D. The paratype is a less aged jaw (Amer. Mus. 10623), illustrated in figures 643A, A1 and 644B, B1 of this Memoir.

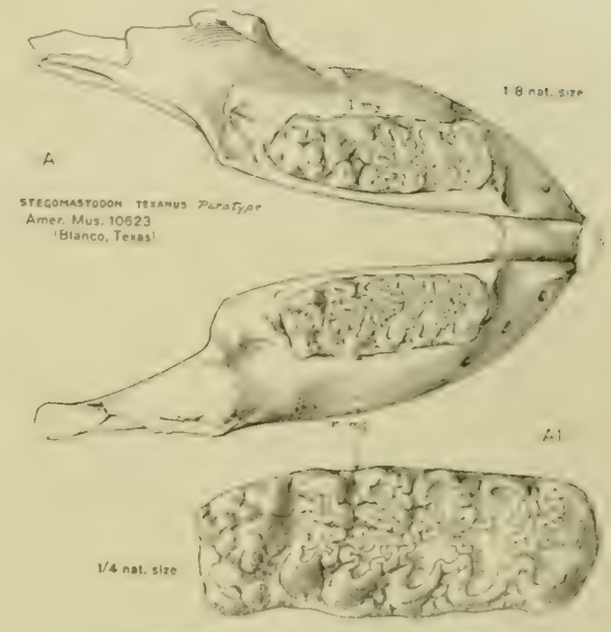
SPECIFIC CHARACTERS BASED ON TYPE, PARATYPE, AND REFERRED SPECIMENS.—(1) Ridge-crest formula of *Stegomastodon texanus:* M3 $\frac{5\,\frac{3}{4}-\frac{1}{2}}{6\,\frac{1}{2}+\text{talon}}$. (2) Tetartolophid, pentalophid, hexalophid, with multiple enamel foldings, quadruple at the front of each ridge-crest, sextuple at the back of each ridge-crest, as compared with the simple condition in the types of *S. mirificus* and *S. successor.* (3) Third inferior molar, M_3, length 223 mm., width 82 mm. index 37; height of metalophid, second crest of crown, 70 mm. (in referred jaw Amer. Mus. 10618). Third superior molar, M^3, length 203 mm., width 83 mm., index 41; height of metaloph, second crest of crown, 62 mm. (in referred palate Amer. Mus. 10698). (4) Ridge-crests of M 2 $\frac{}{3\,\frac{1}{2}}$ M 3 $\frac{5\,\frac{3}{4}-\frac{1}{2}}{6\,\frac{1}{2}+}$. The above *type, paratype,* and *referred* characters are beautifully shown in figures 639, 642 to 645.

ASCENDING MUTATIONS IN THE BLANCO.—It follows from the above definition that *Stegomastodon texanus* is a far more progressive species than *S. successor* or *S. mirificus* and proves that the so-called "Blanco formation" of Texas includes more than one specific stage. It probably represents a long period of geologic time, during which a complete ridge-crest was added, since *S. texanus* is hexalophodont +, while *S. successor* is pentalophodont +, and *S. mirificus* is pentalophodont with a very primitive hexalophid and feeble talonid.

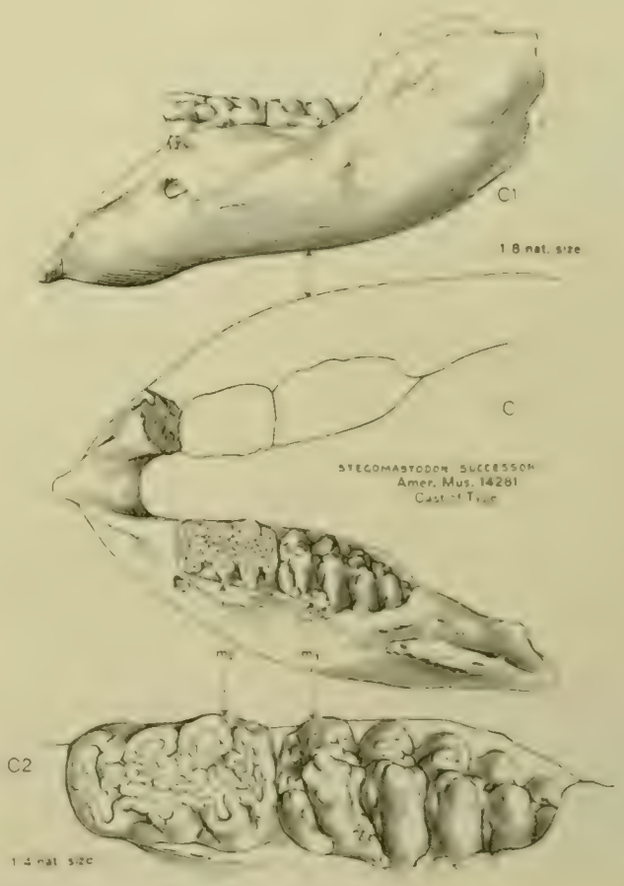
SUPPLEMENTARY CHARACTERS BASED ON TYPE, PARATYPE, AND REFERRED SPECIMENS.—From the above observations and measurements of six progressive specimens which may be reasonably referred to *Stegomastodon texanus,* we derive the following supplementary characters:

Ridge formula of *S. texanus:* Dp 4 $\frac{3}{3}$ M 1 $\frac{3\,\frac{1}{2}}{3\,\frac{1}{2}}$ M 2 $\frac{3\,\frac{1}{2}}{3\,\frac{1}{2}}$ M 3 $\frac{5\,\frac{3}{4}-\frac{1}{2}}{6\,\frac{1}{2}+}$.

Five anterior crests, proto-, meta-, trito-, tetarto-, and pentalophs in superior molars; complex, chœrodont, with supplementary *pericones* on the outer sides, rudiments of same on inner sides. M^3 with low rudimentary sixth crest consisting of from four to five conelets, rudiment of seventh crest or heptaloph.



STEGOMASTODON TEXANUS PARATYPE



STEGOMASTODON SUCCESSOR TYPE

INFERIOR DENTITION OF STEGOMASTODON TEXANUS (A) AND OF S. SUCCESSOR (C)

Fig. 643. Type (C, C1, C2) of *Mastodon* [=*Stegomastodon*] *successor* Cope, compared with paratype (A, A1) of *Stegomastodon texanus* Osborn; from the Blanco, Texas.

BLANCO — A, Paratype adult jaw of *S. texanus* (hexalophodon mut.), Amer. Mus. 10623, Upper Pliocene, Blanco, Texas. One-eighth natural size.

A1, Enlarged r.M_3 of same jaw (*S. texanus* paratype) showing labyrinthine folds of enamel. One-fourth natural size.

BLANCO — C, C1, C2, Type jaws and teeth of *Mastodon* [*Stegomastodon*] *successor* Cope, from the Blanco, Texas. After cast of type (Amer. Mus. 14281). Original in Texas Geological Survey Collection. Ridge formula: $M2\frac{}{3\,\frac{1}{2}}$ $M3\frac{}{+5\,\frac{1}{2}}$. C, C1 one-eighth natural size; C2 one-fourth natural size. Observe brachyodont or subhypsodont elongation of crests; also extreme ptychodonty.

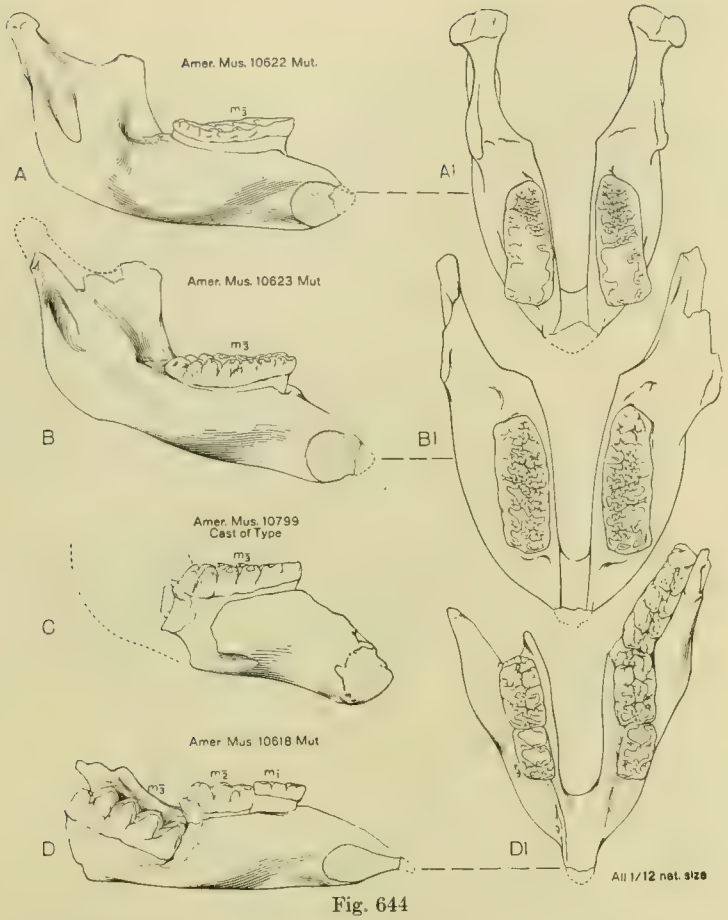


Fig. 644

ONTOGENETIC AND PROGRESSIVE JAW CHARACTERS AND INFERIOR GRINDING TEETH OF STEGOMASTODON

Fig. 644. Lower jaws of *Stegomastodon* showing ascending growth and evolutionary stages, with progressive changes in the form of the jaw, abbreviation of the jaw, and shedding of two anterior lower molars.

BLANCO — A, A1, Type of *Stegomastodon texanus;* HEXALOPHODONT M_3, fully adult, M_3 only in use; symphysis abbreviate; anterior half of teeth greatly worn, posterior half partly worn.

" — B, B1, Paratype of *Stegomastodon texanus;* HEXALOPHODONT M_3, M_3 only in use; symphysis partly abbreviate, ridge-crests still showing labyrinthodont pattern.

"LOUP FORK," NEB. — C, Type of *Stegomastodon mirificus* Leidy; PENTALOPHODONT M_3; ridge-crests small, less hypsodont; symphysis relatively more elongate; M_3 only in use.

BLANCO — D, D1, Juvenile stage of *Stegomastodon successor* or *S. texanus;* pentalophodont M_3; symphysis erect, relatively elongate; first and second true molars, M_1, M_2, still in use, M_3 embedded in the jaw; the pentalophid is fractured in M_3 and the rudimentary hexalophid is entirely broken off.

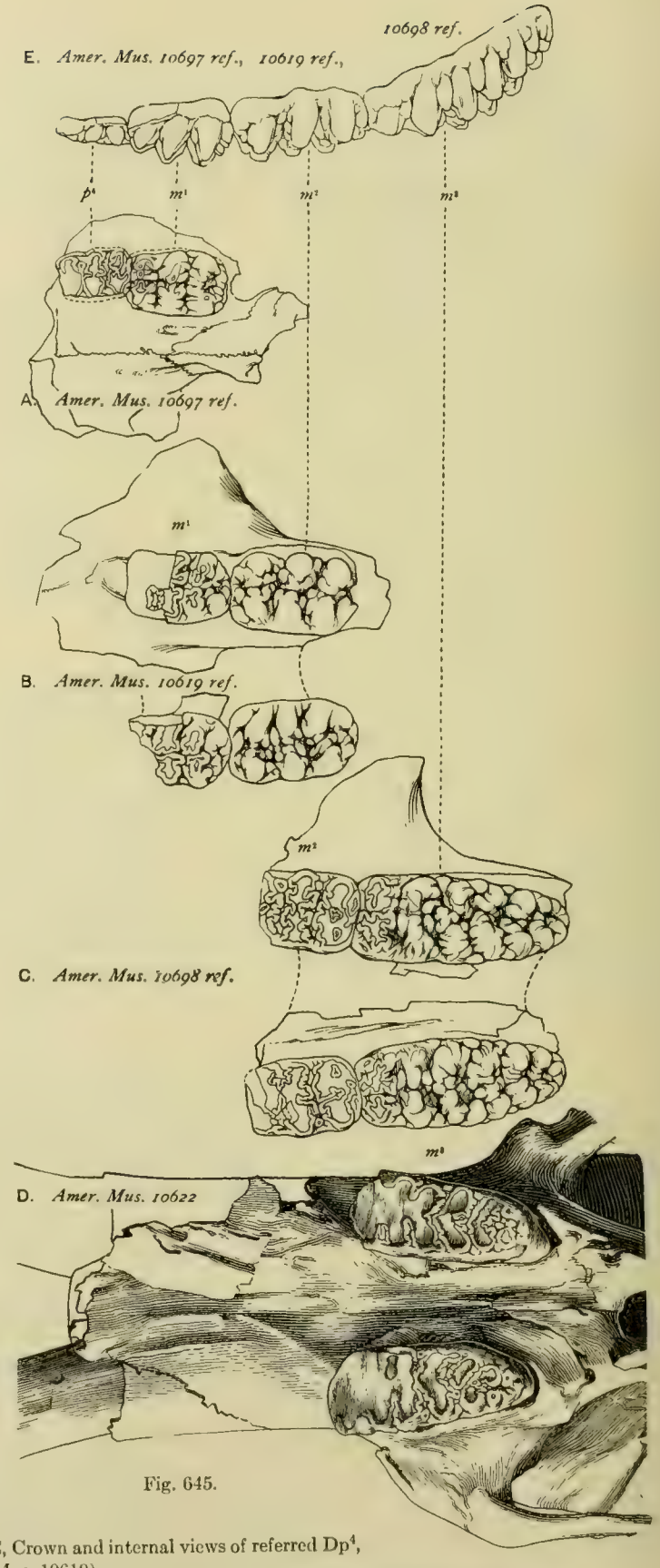


Fig. 645.

SUPERIOR GRINDING TEETH, P^4-M^3, OF STEGOMASTODON TEXANUS

Fig. 645. Palate and maxillary dentition of type (D) of *Stegomastodon texanus* (Amer. Mus. 10622) and of three referred specimens, from the Blanco formation, Upper Pliocene of Texas. American Museum Expeditions of 1900, 1901. One-sixth natural size.

C, E, Internal and crown views of referred M^2, M^3 (Amer. Mus. 10698). A, E, Crown and internal views of referred Dp^4, M^1 (Amer. Mus. 10697). B, E, Palatal and internal views of referred M^2 (Amer Mus. 10619).

The top line is a composition of the dental succession, Dp^4-M^3, derived from three referred specimens, namely, Amer. Mus. 10697, 10619, 10698.

STEGOMASTODON TEXANUS AND S. SUCCESSOR MUTATIONS OF THE BLANCO, AMERICAN MUSEUM COLLECTION

The Blanco formation contains a series of *ascending mutations* chiefly embraced within the collective species *Stegomastodon texanus*. M_3 is pentalophodont + to hexalophodont +.

In *descending* geologic order the principal specimens of *Stegomastodon* discovered and collected for the American Museum by J. W. Gidley are arranged from Gidley's field notes. At the extreme bottom of the formation was found a specimen (Amer. Mus. 10618) with grinding teeth of comparatively simple structure, suggesting the type of *Stegomastodon successor*, while in the uppermost level occurs the highly progressive form of *Stegomastodon texanus* (Amer. Mus. 10698).

STEGOMASTODON TEXANUS

Amer. Mus. 10698
Upper levels of Blanco formation

Palate with M^2, M^3 (Fig. 645 C, E), Blanco formation, Amer. Mus. Exped. 1901. M^2, length 104 mm., width 72 mm., index 69, ridges three and a third. M^3, length 200 mm., width 78 mm., index 39, ridges 6½+. This third superior molar, M^3 (Fig. 645 C, E) is extraordinarily complex. While the ridge formula is $\frac{5\frac{1}{2}+?}{}$, the ridges attain a height of 68 mm.; quadruple trefoils are observed on the proto-, meta-, trito-, tetartolophs; the pentaloph is less elevated; the hexaloph consists of four cones; the heptaloph of a talon with three relatively low conelets. Prominent external *pericones* block the spaces between the five main crests; similar rudimentary internal cones are observed. It would thus appear that this highly chœrodont, ptychoid, labyrinthine, pericone molar belongs to the progressive *Stegomastodon texanus* stage.

Amer. Mus. 10622
A little above middle of Blanco formation

Type of *Stegomastodon texanus* (Figs. 639, 642, 644 A, A1, 645D), Blanco formation of Texas, Amer. Mus. Exped. 1900, J. W. Gidley collector. (See Gidley, Bull. Amer. Mus. Nat. Hist., 1903, Vol. XIX, p. 619): "The specimens of most importance found at this locality were a nearly complete skull and lower jaws of *Dibelodon mirificus* (No. 10622, American Museum Collection), and, the following year, a partial skeleton of a Glyptodont. . . . *Glyptotherium texanum* [Osborn]." This unique specimen consists of skull, jaws, five cervicals, one dorsal, parts of forelimb. The skull and jaws are fully illustrated in figures 639, 642 of this Memoir, also in the composite figures 644 A, A1 and 645 D.

Amer. Mus. 10623
Found in taking out Amer. Mus. 10622, a little above middle of Blanco formation

Paratype lower jaws of *Stegomastodon texanus* (Figs. 643 A, A1, 644 B, B1), Blanco formation, Amer. Mus. Exped. 1900. These half-worn third inferior molar teeth, M_3, measure 225 mm. in length by 83 mm. in width, index 37. As shown in figure 643A, they exhibit six ridge-crests of which the five anterior are highly complicated, proto-, meta-, trito-, tetarto-, and pentalophids; the hexalophid consists of two prominent cones less broad and complicated than the preceding; the heptalophid is more depressed. These teeth apparently serve as a complement to the much worn type molars, M_3 (Amer. Mus. 10622), which measure 223 mm. in length by 82 mm. in width, index 37.

Amer. Mus. 10619
Just above middle of Blanco formation

Palate with M^1, M^2 (Fig. 645 B, E), Blanco formation, Amer. Mus. Exped. 1900. M^1, length 92 mm., width 66 mm., index 72, ridges three and a half. M^2, length 123 mm., width 76 mm., index 62, ridges three and a half. These unworn teeth are highly complicated, or chœrodont; consequently we may confidently refer them to the progressive species *Stegomastodon texanus*.

Amer. Mus. 10697
Lower levels of Blanco formation, bottom of white beds

Referred palate with Dp^4, M^1 (Fig. 645 A, E). Dp^4, length 69 mm., width 46 mm., index 67, three ridges. M^1, length 91 mm., width 61 mm., index 67, ridges three and a third. Amer. Mus. Exped. 1901.

STEGOMASTODON SUCCESSOR AND S. TEXANUS REF.

Amer. Mus. 10585
Bottom of Blanco formation, Mulberry Canyon

Three lower teeth, Blanco formation, Amer. Mus. Exped. 1899.

Amer. Mus. 10618
Extreme bottom of Blanco formation

Lower jaws (Fig. 644 D, D1), Blanco formation, Amer. Mus. Exped. 1900. This jaw contains M_1, M_2, and incomplete M_3, as represented in figure 644 D, D1. M_3 exhibits four perfect ridge-crests with the pentalophid and hexalophid broken away. Consequently the correct ridge formula in this specimen is probably: M 1_3 M $2\frac{}{3\frac{1}{2}}$ M $3\frac{}{5+}$. M_1 measures 82 mm. in length, 61 mm. in width, index 74. M_2 measures 122 mm. in length, 70 mm. in width, index 57. The ridge-crests in M 3 are $\frac{}{5\frac{1}{2}}$, and of comparatively simple trefoil structure, suggesting that of the type of *Mastodon successor* Cope. A distinctive feature of this jaw is the presence of an internal pericone in the anterior valley of M_2.

Stegomastodon arizonæ Gidley, 1924, 1926

Figures 634, 635, 640, 646–649

San Pedro beds, uppermost Pliocene, Curtis Flats, Cochise County, Arizona.

This specific stage is somewhat more progressive than *Stegomastodon texanus* of the Blanco of Texas, and much more progressive than *Stegomastodon mirificus* of the "Loup Fork of Platte River," Nebraska. The type and referred specimens of *Stegomastodon arizonæ* occur in a horizon which contains primitive species of the true horse described by Matthew (1924) as *Plesippus*, as well as species of *Hipparion* and of *Pliohippus*. The rich fauna of rodents, artiodactyls, carnivores, and edentates, as well as of proboscideans, justifies the conclusion of Gidley that the San Pedro beds are "older than Pleistocene but somewhat more recent in geologic age than the Blanco."

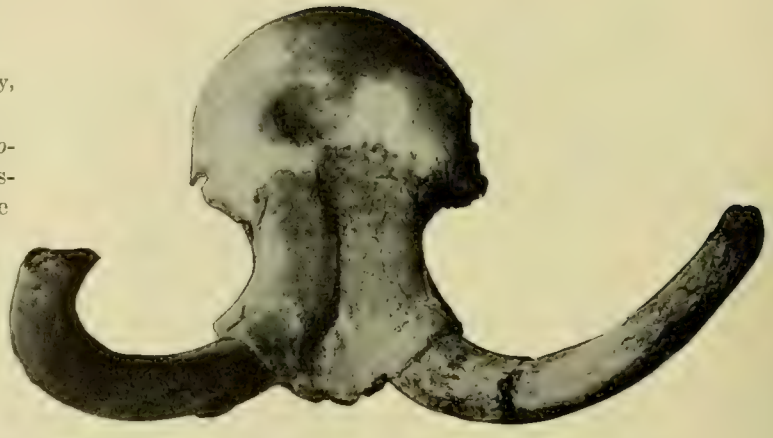


Fig. 647. Type cranium of *Stegomastodon arizonæ* Gidley, 1926 (Nat. Mus. 10707), after photographs kindly furnished the author by James W. Gidley (cf. Gidley, 1926, Pl. xxxiv, a, b). Observe treble trefoils in the second ridge-crest of $1.M^3$, also posterior position of palatal opening. Meas.: M^2, 95 x 86 mm.; M^3, 212 x 97 mm.

(Right) Anterior view of skull and tusks, about one-sixteenth natural size.

(Left) Palatal view of cranium, about one-eighth natural size.

Fig. 646. Type mandible of *Stegomastodon arizonæ* Gidley, 1926 (Nat. Mus. 10707). After photograph kindly furnished the author by James W. Gidley (cf. Gidley, 1926, Pl. xxxv, a, b). About one-sixth natural size. Observe delicate and narrow rostrum, also five ridge-crests in M_2. Meas.: M_2, 110 x 92 mm.; M_3, 230 x 98 mm. Length of mandible, condyle to symphysis 740 mm.

Stegomastodon arizonæ Gidley, 1926. "Fossil Proboscidea and Edentata of the San Pedro Valley, Arizona." U. S. Geol. Surv. Prof. Paper 140–B, p. 86. First use of the name in Osborn (Osborn, 1924.634, p. 4) from Gidley manuscript.

Type.—(Gidley, p. 86): "Portion of skeleton of a young adult male, including the base portion of the skull with tusks and cheek teeth in place; the lower jaws; both fore limbs (one with nearly complete foot); parts of both hind limbs; the pelvis; and several of the more characteristic vertebræ and ribs (catalog No. 10707, U. S. National Museum)." Horizon and Locality.—Curtis Flats, about fourteen miles southeast of Benson, Cochise County, Arizona, sec. 25, T. 18 S., R. 21 E. Type Figure.—*Op. cit.*, Pls. xxxiii–xxxv, Pl. xxxviii, figs. 1–3, Pl. xxxix, figs. 1–3.

Type Description (Diagnosis).—(*Op. cit.*, p. 86): "Skull short; rostrum short and bent sharply downward on the plane of the palate; lower jaws with short symphysis, spoutlike chin and no tusks; a single tooth in each jaw in old individuals, as in *Stegomastodon mirificus* (Leidy); tusks without enamel, large, stout, much curved, and widely spreading so that at the point of exit from the skull they diverge at right angles to each other; second molars when present, tetralophodont, or nearly so; third molars sextalophodont or septalophodont, with heel; lophs when unworn relatively high, with summits of main cusps closely approached, leaving the shallow longitudinal median valley nearly closed; principal cusps of the last lower molar not arranged in straight lines antero-posteriorly, as in most species of mastodons, but curving outward posteriorly, giving to the tooth crown a twisted appearance."

"The cusps of these molars, above and below, arise one above the other in the jaw, so that the anterior lobes, appearing much earlier, are deeply worn before the more posterior ones come into use. These last two are progressive characters which parallel or are rather tending toward the condition of tooth replacement found in the true elephants and which mark this species of mastodon as having advanced, at least in this respect, much beyond the better-known later survivor of this great group of Proboscidea, *Mastodon americanum*. The tendency toward elephantlike development of the last molars of *Stegomastodon arizonae* is an important difference to be noted in comparing it with *S. mirificus*, the latter being a less progressive species. In *S. mirificus* the summits of the lophs are more nearly on the same plane and are more evenly worn by use, as in *Mastodon americanum*. This progressive feature is also strongly marked in certain species of Old World mastodons and is likewise present, but to a much less degree, in certain other American species, as *Megabelodon lulli* Osborn [Barbour] and *Tetrabelodon* [*Tetralophodon*] *campester* Cope."

Fig. 648. Restoration of the physiographic and faunal characters of the San Pedro valley of southern Arizona in uppermost Pliocene time, after the explorations of Gidley, 1926. Drawn by Charles R. Knight in the year 1926, under the direction of Henry Fairfield Osborn.

The scene represents the very arid period in which are congregating mammals from three continents, namely, *Glyptotherium arizonæ* from South America, a herd of camels (*Pliauchenia spatula*) and of horses (*Plesippus simplicidens*) from North America, while a troop of giant Humboldtines (*Stegomastodon arizonæ*) are drifting in from the northwest. The camels, while not listed by Gidley in the San Pedro formation, no doubt belonged to this geologic period.

REFERRED MATERIAL, U. S. NAT. MUS.—(*Op. cit.*, p. 86): "(1) Portions of a skeleton of a moderately old male, including the basal portion of the skull with teeth and tusks in place; the lower jaws; a fore limb and foot lacking only the proximal end of the humerus and the greater portion of the scapular blade; a few ribs and vertebræ; and the sacrum with parts of the pelvis (catalog No. 10556, U. S. National Museum). Found at about the same level as the type specimen, and about 100 yards distant. (2) A complete hind foot and distal end of tibia associated with a lower jaw lacking teeth (catalog No. 10917, U. S. National Museum). Found about 50 feet from No. 10556 and at the same level."

SAN PEDRO FORMATION, ARIZONA. GEOLOGIC AND FAUNAL CHARACTERS

POST-BLANCO, UPPERMOST PLIOCENE AGE, GIDLEY, 1926.—The fossil bearing beds of the San Pedro valley occur in Cochise County, Arizona, in a strip forty miles from north to south lying on either side of the San Pedro River; they are best exposed at two localities known as Benson and Curtis Flats; they are doubtless the equivalents of the Gila formation which heretofore has been considered as Pleistocene in age. As described geologically by Kirk Bryan ("Geology and Water Resources of San Pedro Valley, Ariz." U. S. Geol. Surv. Water-Supply Paper. Unpublished.) and faunistically by J. W. Gidley ("Preliminary Report on Fossil Vertebrates of the San Pedro Valley, Arizona," U. S. Geol. Surv. Prof. Paper 131–E, 1922, pp. 119–131; "Fossil Proboscidea and Edentata of the San Pedro Valley, Arizona," U. S. Geol. Surv. Prof. Paper, 140–B, 1926), they are regarded as older than Pleistocene but somewhat more recent in geologic age than the Blanco. Near Saint David, Arizona, they consist principally of red clays, sands, and soft limestones that were deposited in salt lakes. These beds interfinger laterally with arkosic gravels and conglomerates typical of deposition on arid alluvial slopes. The bones mostly occur in greenish clays and tufaceous clays deposited in springy and swampy areas on the margins of the salt lakes.

ANCIENT WATER-HOLES.—The character of the clay in which the skeletons of *Stegomastodon* and of *Glyptotherium* were found and the condition and disposition of the bones point to the existence of water-holes in these localities. Some of the animal remains were buried complete; of others only a single bone was found. Gidley points out that the bogged remains of some of the animals were

trampled by their contemporaries. The carapace of the superb *Glyptotherium arizonæ*, according to Gidley, may have been crushed in by the feet of a *Stegomastodon arizonæ;* similarly, the skull of the type of *Stegomastodon arizonæ* was crushed and eroded while partially buried in a Pliocene bog hole. The fauna is now regarded as slightly more recent than that of the Blanco, but in our opinion this cannot be positively determined until the species of horses as well as of proboscideans are more closely compared with specimens as yet uncollected from other localities. Compare Gidley, 1922.1, p. 120, for tentative list; also Gidley, 1926.1, pp. 86–94.

RODENTIA

SCIURIDÆ: *Citellus* (two species).
GEOMYIDÆ: *Geomys* (two species); *Cratogeomys* (one species).
HETEROMYIDÆ: *Dipodomys* (one species).
MURIDÆ: *Subfamily* Cricetinæ (four genera, nine species).
Subfamily Neotomeniæ (one genus and one species).
Subfamily Microteinæ (*Neofiber*, one species).
LEPORIDÆ: *Lepus* (three species); *Sylvilagus* or *Brachylagus* (one species).

PERISSODACTYLA

EQUIDÆ:
Plesippus (near *Equus semiplicatus* Cope).
Hipparion Gidley (new species not published). Benson locality.
Pliohippus (new species not published). Benson locality.

ARTIODACTYLA

Merycodus sp. near *M. necatus*. Benson locality.
Cf. *Merycodus* near *M. osborni*. Possibly *Capromeryx*. Curtis Flats locality.
Cf. *Odocoileus* n. sp. Curtis Flats locality.

CARNIVORA

Canis, of the coyote group in tooth structure but with a primitive Miocene limb structure. Curtis Flats locality.
Canid, large species, possibly *Tephrocyon*. Benson locality.
Felid, large species. Benson locality.
Mustelid, small. Curtis Flats locality.
Mustelid, small species, Benson locality (Amer. Mus. Coll.).

EDENTATA

Glyptotherium arizonæ Gidley, type specimen including (a) twelve caudal vertebræ as compared with the thirteen caudals preserved in *Glyptotherium texanum* Osborn from the Blanco, (b) fore- and hindlimbs complete, (c) lower jaw with teeth, nearest to *Glyptotherium texanum*, (d) tail armature with eight free osseous rings, three osseous rings coalesced in a terminal cone.

PROBOSCIDEA

Stegomastodon arizonæ Gidley, type specimen a young adult, nearly complete animal (Nat. Mus. 10707), Cochise County, Arizona, found in a bed of greenish brown clay, probably a swampy area in the vicinity of a salt lake. Old adult skull, jaws, and parts of the skeleton (Nat. Mus. 10556) referred to *Stegomastodon arizonæ* found 100 yards distant. Curtis Flats locality.

Anancus bensonensis Gidley, type specimen the greater part of the base portion of a skull (Nat. Mus. 10538). Benson locality. [=*Cordillerion bensonensis*.]

UPPERMOST PLIOCENE. SUMMARY (GIDLEY, 1922, P. 121, CF. 1926).—"The facts that there are here two or three species of true horse (*Equus* [=*Plesippus*]) and that the rodents are all referable to modern genera, some of which are found living in this general region, may suggest Pleistocene age. But to offset this evidence of a seemingly more modern fauna, the mastodons and glyptodonts are of distinctly Pliocene types, and one of the canids, though modern in skull and dental modifications, has the type of humerus belonging to the Miocene and Pliocene canids, in that the entepicondylar foramen is prominently present. This feature and the presence of *Hipparion*, *Pliohippus*, and *Merycodus*, together with the fact that the 15 or more species of rodents include no living species, constitute rather conclusive evidence of a faunal assemblage that is older than Pleistocene."

(Gidley, letter, April 18, 1924): "Curtis Flats Locality. We [Dr. Kirk Bryan and Dr. J. W. Gidley] are both of the opinion that there can be no question of the association of a primitive *Equus* [=*Plesippus* Matthew] with the *Stegomastodon arizonæ*, *Glyptotherium*, etc. The skull came from abut 20 feet higher than did the *Stegomastodon* skeletons of three years ago, but three of the *Glyptotherium* specimens including the one I got this year came from practically the same level as the horse skull. There also seems now to be no doubt that, although a single geological unit, there is a slight difference in age between the beds of the Benson locality and the Curtis Flats locality."

MATERIALS OF STEGOMASTODON ARIZONÆ IN NATIONAL MUSEUM.—The type (Nat. Mus. 10707), a relatively young animal, consisting of skull, jaws, and greater part of the skeleton, now mounted in the United States National Museum (Fig. 634); it was discovered in the San Pedro beds, Arizona, associated with the remains of *Glyptotherium arizonæ*.

Referred old adult male (Nat. Mus. 10556), found about one hundred yards distant from the type skeleton on the same geologic level; distinguished (1) by subquadrangular tusks, grooved on the outer superior surface; (2) by the obliquity of the superior cusps; (3) by the deep channel in the symphysis, also by the deep cavity and channel in the palate.

SKELETAL CHARACTERS OF STEGOMASTODON ARIZONÆ

The superb type and referred skulls of this animal as described by Gidley were found associated with a nearly complete skeleton (Figs. 634, 640) and afford for the first time a complete knowledge of this remarkable migrant from Asia and western Europe in the form in which it reached the semi-arid plains of Texas and Arizona.

This skeleton of the *Stegomastodon arizonæ* type (Nat. Mus. 10707) was collected for the U. S. National Museum by James W. Gidley in 1921 and mounted under his direction in 1922. The principal measurements by Gidley are as follows:

	Mm.
Total length of skeleton as restored	3605
Height of tallest dorsal spine (D4)	425
Length of presacral column, (mostly restored)	2035
Basal length of skull (condylar notch to extremity of premax.)	820
Length of last two dorsals and the three lumbars (preserved in articulated sequence)	465
Length of 1st rib (estimated)	600
" " 4th rib (around curve)	950
" " scapula	765
" " humerus	850
" " radius	630
" " forefoot (articulated)	280
Total length of forefoot and limb (as mounted)	2485
Greatest width of pelvis	1475
External point of ilium to acetabulum	440
Acetabulum to distal end of ischium	345
Height, top of spine of sacrum to floor	2265
" top of tallest dorsal spine to floor	2420
Center of acetabulum to ant. border of 1st rib	1985
Length of femur	1010
" " tibia	645
Total length of hindlimb and foot	1890

These measurements are all taken from the actual bones; restored bones are eliminated.

Proportions.—The estimated height of the skeleton at the shoulder is 8 ft. 3 in. Recalling the fact that this is a relatively young animal, we should expect the adult to attain fully the height of 9 ft. shown by the Warren Mastodon skeleton of *M. americanus*. Fortunately the anterior dorsal spines are finely preserved opposite the scapulæ and enable us to estimate the height very correctly. Some of the relative measurements of this skeleton and that of the Warren Mastodon in the American Museum are interesting for comparison:

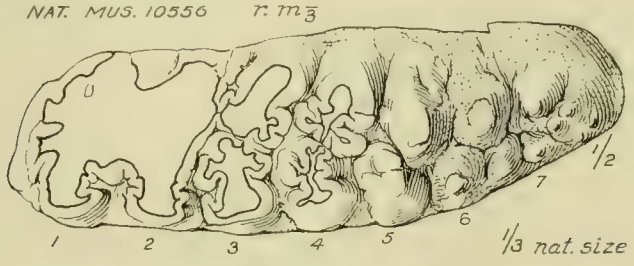
Skeletal Characters.—Several characters of the *Stegomastodon arizonæ* observed by Gidley in the type skeleton are those common also to other Proboscidea, namely: (1) The distal cross axis of the humerus is twisted inwardly so as to throw the foot inwards; (2) the anterior thoracic ribs opposite the scapulæ are flattened or incurved opposite the junction of the head of the humerus and the scapulæ, thus accommodating themselves to the combined expansion for the head of the humerus and distal portion of the scapula opposite the scapulo-humeral joint. (3) In skeletal proportion the *Stegomastodon* skeleton is more elephant-like, that is, taller and shorter than the excessively long, low-bodied *Mastodon americanus* type.

Skull Characters.—Special features of the *S. arizonæ* type skull are the following: (1) A deep channel in the center of the mandibular symphysis, also (2) a deep channel and cavity at the roof of the palate; (3) the incisive alveoli are widely split apart at the base so that the maxillæ are excessively broad; (4) the tusks are short, very massive, widely split apart at the base, but they rapidly incurve so that as in *Mastodon* and *Elephas* they tend to come together; (5) the tusks are not circular in section as in *Mastodon*, but *subquadrangular* and grooved on the outer superior surface.

Type Grinding Teeth.—The superior and inferior grinding teeth of the type specimen (Nat. Mus. 10707), a relatively young animal, and those of the referred specimen (Nat. Mus. 10556), an elderly adult animal, afford a means of clear and close comparison with various specimens referred to *Stegomastodon texanus* in a collection made in the Blanco by J. W. Gidley in 1899–1901. It appears that the type (Nat. Mus. 10707) and the referred skull (Nat. Mus. 10556) belong to the same species. They are in the seven and a half crested stage, as in *Stegomastodon texanus* (hexalophodont mut.) of Osborn, and might be termed *heptalophodont* or seven crested. There is in M_3 also a rudimentary anterior crest (pro-protolophid) forming in front of the protolophid and a rudimentary crest (?octalophid) forming behind the heptalophid; thus the teeth may be described as heptalophodont progressing towards a supplementary crest formation both at the front and the back.

	Warren Mastodon (Amer. Mus. 9951)	*Stegomastodon arizonæ* Type Skeleton (Nat. Mus. 10707)
Length:		
Base of tusks to drop of tail	4550 mm. (14 ft. 11 in.)	3605 (11 ft. 9⅞ in.)
Total length of femur	1060 (right)	1010
" " of humerus	950 (right)	850
" " of cervical vertebræ	510	450 (restored)
" " of dorsal vertebræ	1875	1445 (restored in part)
" " of manus	281	280
" " of pes	212 (right)	210 (taken from Nat. Mus. 10917)
Height:		
Total height of scapula	900	765
" " of pelvis	1115	1000 (post. end of pub. to spine of ilium)
Estimated height of shoulder	2518 (from base to upper tip of scapula)	2520
" " of pelvis	2668	2240
Width:		
Total width of pelvis	1800	1475

The accompanying diagram (Fig. 649) from a pencil sketch by Osborn of a referred third right inferior molar, r.M_3, of *Stegomastodon arizonæ* (Nat. Mus. 10556) exhibits very clearly a seven and a half crested stage, as compared with the five and a half plus (6+) crested condition of *Stegomastodon mirificus.*



Referred Third Right Inferior Molar of Stegomastodon arizonæ

Fig. 649. A referred third right inferior molar, r.M_3, of *Stegomastodon arizonæ* (Nat. Mus. 10556, cast Amer. Mus. 21923), one-third natural size.

This seven and a half crested molar, with double trefoils and cement, is highly progressive. Observe that it is somewhat more progressive than the *S. texanus* type (Fig. 642), but less progressive than the *S. aftoniæ* type (Fig. 650).

The reader is referred to the very important second paper of Gidley entitled "Fossil Proboscidea and Edentata of the San Pedro Valley, Arizona," U. S. Geol. Surv., Prof. Paper 140—B, published in the year 1926, in which detailed measurements are given of several of the members of the remarkable San Pedro uppermost Pliocene fauna.

Comparison with Mastodon americanus (Gidley, 1926, pp. 89, 90). —"In the Indiana specimen [*Mastodon americanus*] the spine of the first dorsal approaches in height those of the second and third, which are equal and the highest of the series. In the Arizona specimen [*Stegomastodon arizonæ*] the fourth dorsal spine is the highest, the second is next, the third a little shorter, and the first still shorter, being relatively much shorter than the corresponding one of the Indiana [true] mastodon."

"*General features of the skeleton as mounted.*—In addition to the characteristics pointed out in the above detailed description, a few features worthy of note are presented in the general skeletal structure of *Stegomastodon arizonae* as restored and mounted. The general proportions of the skeleton are in part conjectural. However, the length of the back, computed from the few characteristic vertebrae preserved, and the definitely known features of the skull indicate rather clearly that *S. arizonae* was relatively higher and shorter than *Mastodon americanum;* both the pelvis and the skull are more elephantlike in general form, but the tusks are much more divergent than is usual in any proboscidean."

Besides the type skeleton there are considerable portions of a referred skeleton (Nat. Mus. 10556) provisionally referred to *Stegomastodon arizonæ*; this differs from the type in the following respects (Gidley, 1926, p. 90): "(1) It represents a larger individual (see table of comparative measurements, p. 87); (2) the cheek teeth are reduced to a single one (m^3) in each jaw; (3) m^3 [m3], both upper and lower, is relatively and actually narrower than that of the type, and, although much worn, indicates clearly that the homologous lophs are relatively less elevated and the valleys correspondingly less open; (4) the tusks are notably larger and less cylindrical, being subquadrate in cross section; (5) the symphysis of the lower jaw is deeper; and (6) the palate is deeply arched and about twice the width of that of the type skull."

4. THE PLEISTOCENE HUMBOLDTINE STEGOMASTODON AFTONIÆ OSBORN, 1924, AND THE MORE ANCIENT S. PRIESTLEYI HAY AND COOK, 1930

Stegomastodon aftoniæ Osborn, 1924

Figures 580, 650

Lower Pleistocene, Aftonian of Iowa,[1] *fide* Calvin, Shimek, and Hay. About two miles east of Akron, Plymouth Co., Iowa.

The types of this most progressive and geologically recent species were described by Calvin (1909, p. 355) and compared with Leidy's *Mastodon mirificus;* he published (Pl. xxvii) the figure of the third right superior molar, r.M^3. The locality was a well, sunken probably to the Nebraskan drift, in which were found at a depth of twenty feet some fragments of tusks, some cranial bones, and two grinding teeth which Osborn (1924.634) made the types of his new species *Stegomastodon aftoniæ*, in reference to the supposed Aftonian or *1st Interglacial* age of this progressive species. Shimek (Bull. Geol. Soc. Amer., Vol. XXI, pp. 125–127) regarded the deposits containing the types as of Aftonian age; this opinion was accepted by Hay (1914, p. 377), who refigured one of the type teeth, referring it to *Rhabdobunus mirificus*, and consequently regarding it as establishing the Lower Pleistocene age of Leidy's type of *Mastodon mirificus.*[2] *Stegomastodon aftoniæ*, however, proves to be far more progressive than *S. mirificus*, as shown in the following comparison made by Osborn (1924.634, pp. 3, 4):

"3. *Stegomastodon aftoniæ*, Osborn's type of Iowa, M^3, seven ridge-crests plus well-developed talon; highly labyrinthodont double trefoils on proto-, meta-, trito-, tetarto-, and ?pentalophs; hexaloph, two simple, widely separated cones; heptaloph, two rudimentary cones closely conjoined. Since the inferior molars of *Stegomastodon* are much more progressive than the superior molars, we should expect to find M_3 in the Aftonian stage with nearly eight ridge-crests. M_3 (?) octalophodont."

"2. *Stegomastodon arizonae*, Gidley's type of Curtis Flats, Arizona, M_3, seven and a half ridge-crests. M_3 heptalophodont."

"1. *Mastodon mirificus*, Leidy's type of Nebraska, six [5½+] ridge-crests plus a very rudimentary talon; double cones and incipient double trefoils on proto-, meta-, tritolophids. M_3 hexalophodont."

Osborn does not consider that this geologic age is fully established but regards the specimens themselves as demonstrating the probability of their Pleistocene and perhaps Aftonian age; the geologic age of the types, however, awaits further verification.[1]

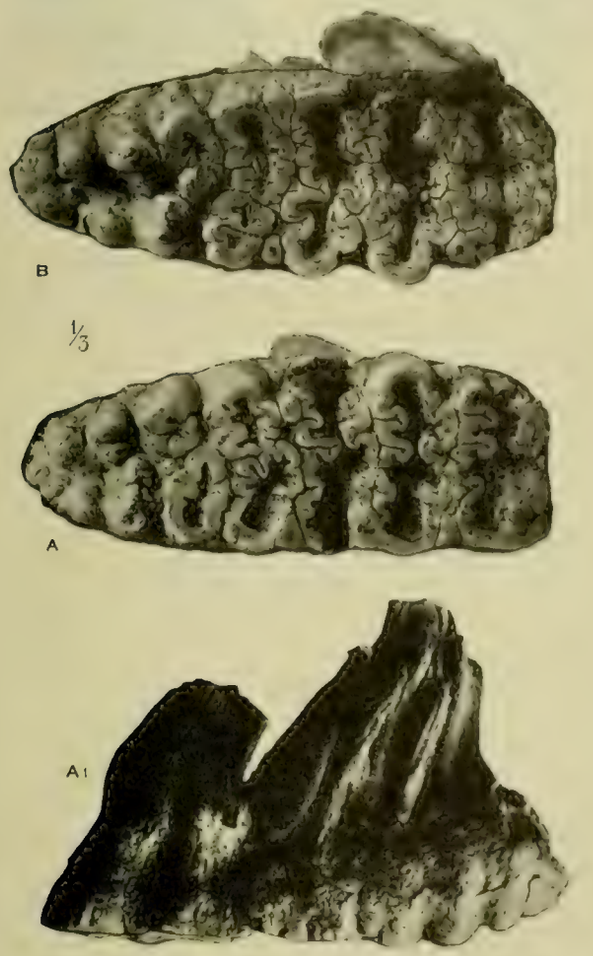
Stegomastodon aftoniæ Osborn, 1924. "Additional Generic and Specific Stages in the Evolution of the Proboscidea." Amer.

[1][Determined by Messrs. Lugn and Schultz as of Yarmouth rather than of Aftonian age, that is, Lower to Middle Pleistocene (see footnote on p. 671 above).—Editor.]

[2][Lower to Middle Pleistocene age (Lugn and Schultz, 1934.1, p. 372).—Editor.]

Mus. Novitates, No. 154, December 24, 1924, p. 3. TYPE.—"A third right superior molar, r.M^3 (Univ. Iowa Coll. 213, cast Amer. Mus. 2573), and a left superior molar, l.M^3 (Univ. Iowa Coll. 212)." HORIZON AND LOCALITY.—"About two miles east of Akron, Plymouth County, Iowa, section 33, township 93 north, range 48 west, twenty feet below the surface." Lower Pleistocene, Aftonian of Iowa, *fide* Calvin, Shimek, and Hay.[1] TYPE FIGURE.—Figure 650 of the present Memoir.

CALVIN (1909, PP. 355, 356).—Calvin's description of the type teeth and figure of the right superior molar, r.M^3, is to be found in the Bulletin of the Geological Society of America, Vol. 20, 1909, pp. 355, 356, Pl. 27: "Probably the most important of the recent additions to our knowledge of the Aftonian mammals comes in the form of two molars of *Mammut mirificum*, or *Mastodon mirificus* Leidy. These teeth were found in Aftonian gravel which was penetrated in digging a farm well near Akron, in Plymouth county, Iowa. They are well worn down by use, and show the characteristic features of this remarkable species unusually well (plate 27). The teeth are the last of the upper molar series—one right, one left. With them were found portions of the tusks and a large number of pieces of the cavernous cranial bones. A part of the maxillary still adheres to the left molar. The left tooth measures 8¾ inches [=230 mm., Hay] long and 3¼ inches wide across the second ridge [83 mm.]. The right tooth is slightly smaller, 8½ inches [=216 mm., Hay] long, and the corresponding widths are also somewhat less."



TYPE SUPERIOR MOLARS OF STEGOMASTODON AFTONIÆ
ALL FIGURES ONE-THIRD NATURAL SIZE

Fig. 650. Type superior molars of *Stegomastodon aftoniæ* Osborn (Univ. Iowa Coll. 213, 212), discovered about two miles east of Akron, Plymouth County, Iowa, section 33, township 93 north, range 48 west, twenty feet below the surface. After original photographs by Samuel Calvin, received through the courtesy of Dr. George F. Kay.

A, Crown view of right superior molar, r.M^3 (Univ. Iowa Coll. 213, cast Amer. Mus. 2573), originally figured by Calvin, 1909, Pl. XXVII, as follows: "Grinding surface of the last superior right molar of *Mammut mirificum* Leidy, from Aftonian gravel penetrated in digging a well near Akron, Iowa." It was refigured by Hay, 1914, Pl. L.

A1, Inner face of same tooth as above, namely, right superior molar, r.M^3 (cf. Hay, 1914, Pl. XLIX, fig. 2).

B, Crown view of left superior molar, l.M^3 (Univ. Iowa Coll. 212).

SPECIFIC CHARACTERS.—The length of the right tooth (Fig. 650, A, A1) as measured by Calvin is 216 mm., of the left tooth (Fig. 650, B) is 222 mm. by 83 mm. at the second cross-crest. As measured by Hay, the length of the left tooth (B) is 230 mm. In both right and left teeth the ridge-crest formula is M $3\frac{7+}{7+}$. The five anterior crests, proto- to pentalophs inclusive, are more complex; the hexaloph consists of two double cones less complex, the heptaloph consists of two double cones widely separated, the octaloph consists of two rudimentary cones constituting a clearly defined talonid in B. The labyrinthine enamel foldings, especially of the protoloph to the tetartoloph, reveal double *trefoils* both on the inner and outer cones; consequently the deep infoldings of the enamel are quadruple to quintuple, as clearly shown in the tetartoloph of B. The crown as a whole presents a labyrinthine pattern produced by these elaborate and deep enamel foldings.

The species of *Stegomastodon* appear to be arranged in ascending geologic order as follows:

PLIOCENE, LOCALITY (?)

Stegomastodon chapmani Hays. Ridge-crest formula: M 3 unknown, single trefoils, slight enamel infoldings. Cones alternating.

UPPER PLIOCENE, BLANCO, LOWER LEVELS

Stegomastodon successor Cope. Ridge-crest formula: M 3 $\frac{5+}{5+}$. Pentalophid simple, biconed; hexalophid rudimentary. Double trefoils. Elongate, pointed rostrum (Fig. 641).

UPPER PLIOCENE[2] OF NEBRASKA

Stegomastodon mirificus Leidy. Ridge-crest formula: M3 $\frac{5+}{5+(6+)}$. Each ridge-crest composed of two main cones divided by shallow grooves into two conelets. Double trefoils. Enamel infolded, relatively simple. Rostrum of jaw relatively prominent.

UPPER PLIOCENE, SAN PEDRO

Stegomastodon arizonæ Gidley. Ridge-crest formula: M 3 $\frac{6+}{7+}$, incipient quadruple trefoils, enamel less deeply infolded.

UPPER PLIOCENE, BLANCO, MIDDLE AND UPPER LEVELS

Stegomastodon texanus Osborn. Ridge-crest formula: M 3 $\frac{5+-6}{6+}$, quadruple trefoils, enamel infolded.

PLEISTOCENE, AFTONIAN(?)[1]

Stegomastodon aftoniæ Osborn. Ridge-crest formula: M $3\frac{7+}{7+}$, quadruple trefoils, enamel deeply infolded.

[1]See footnote 1 on previous page.
[2]See footnote 2 on previous page.

Stegomastodon priestleyi Hay and Cook, 1930

Figure 651

Lower levels of gravel pit near Frederick, Tillman County, Oklahoma.

The gravel pit, lower levels, belonging to Mr. A. H. Holloman near Frederick, Oklahoma, yields material from both the Upper Pliocene (e.g., *Stegomastodon*) and the Lower Pleistocene (e.g., *Archidiskodon haroldcooki*), indicating that the molar type fragment of *Gomphotherium priestleyi* is a washout or remanié specimen from an older horizon or survival into the Lower Pleistocene.

Gomphotherium priestleyi Hay and Cook, 1930. "Fossil Vertebrates Collected Near, or in Association With, Human Artifacts at Localities Near Colorado, Texas; Frederick, Oklahoma; and Folsom, New Mexico," Proc. Colo. Mus. Nat. Hist., Vol. IX, No. 2, Oct. 20, 1930, pp. 31, 32. TYPE.—(*Op. cit.*, p. 31): "The tooth is taken to be the lower right second molar. All that is preserved is the large hind talon, the hindmost crest, and the rear half of the penultimate crest. There were probably originally three crests." Colo. Mus. 1062. HORIZON AND LOCALITY.—About one mile north of Frederick, Tillman County, Oklahoma, from a commercial sand and gravel pit operated by Mr. A. H. Holloman. The pit is situated in the top of the highest ridge of the vicinity. TYPE FIGURE.—*Op. cit.*, Hay and Cook, 1930, Pl. XII, figs. 1, 2.

Osborn, 1933: The type is certainly not referable to *Gomphotherium* [= *Trilophodon*] because of its large double trefoils; it is comparable rather to a fragment of a right second inferior molar of a member of the *Stegomastodon mirificus* phylum, retaining the third ridge-crest and biconed talonid.

Fig. 651. TYPE OF STEGOMASTODON PRIESTLEYI

Type second right inferior molar of *Gomphotherium priestleyi* Hay and Cook, 1930, Pl. XII, figs. 1, 2. One-half natural size.

Stegomastodon primitivus sp. nov.

From northeast of Ainsworth, Nebraska

For description and figures of this new species, see Appendix to the present Volume I.

Plate X. Phylogeny of Mœritherioidea, Deinotherioidea, Mastodontoidea, 1934

This chart was published in August of 1934 (Osborn, 1934.926, fig. 3). The accompanying key is essentially the same as the list of species appearing on pages 276 to 283. Type descriptions and figures of the new species mentioned in this list, namely, *Rhynchotherium browni*, *Tetralophodon fricki*, *Pentalophodon falconeri*, and *Anancus properimensis*, will be found in the present Memoir. For Osborn's final diagram, see Plate XI opposite.

I. *Mœritherium*
- 5. *Mœritherium andrewsi*
- 4. *Mœritherium trigodon*
- 3. *Mœritherium lyonsi*
- 2. *Mœritherium gracile*
- 1. *Mœritherium aneestrale*

II. *Deinotherium*
- 5. *Deinotherium giganlissimum*
- 4. *Deinotherium giganteum*
- 3. *Deinotherium bavaricum*
- 2. *Deinotherium hungaricum*
- 1. *Deinotherium hobleyi*

III *Rhynchotherium*
- 5. *Rhynchotherium falconeri*
- 4. *Rhynchotherium shepardi edense*
- 3. *Rhynchotherium browni* sp. nov.
- 2. *Rhynchotherium tlascalæ*
- 1. *Rhynchotherium spenceri*

IV *Blickotherium*
- 2. *Blickotherium blicki*
- 1. *Blickotherium euhypodon*

V. *Aybelodon*
- 3. *Aybelodon hondurensis*

VI. *Zygolophodon*
- 5. *Zygolophodon borsoni*

VII. *Turicius*
- 6. *Turicius wahlheimensis*
- 5. *Turicius virgulidens*
- 4. *Turicius alticus*
- 3. *Turicius turicensis*
- 2. *Turicius simorrensis*
- 1. *Turicius tapiroides*

VIII *Mastodon, Miomastodon, Palæomastodon*
- 6. *Mastodon americanus*
- 4. *Miomastodon merriami*
- 3. *Palæomastodon bradnelli*
- 2. *Palæomastodon intermedius*
- 1. *Palæomastodon parvus*

IX. *Pliomastodon*
- 5. *Pliomastodon vexillarius*

X. *Trilophodon* of Eurasia
- 12. *Trilophodon gaillardi*
- 11. *Trilophodon macrognathus*
- 10. *Trilophodon chinjiensis*
- 9. *Trilophodon austro-germanicus*
- 8. *Trilophodon angustidens*
- 7. *Trilophodon palæindicus*
- 6. *Trilophodon pontileviensis*
- 5. *Trilophodon cooperi*
- 4. *Phiomia pygmæus*

XI. *Trilophodon* (*Tatabelodon*). 'Oblique-tuskers'
- 8. *Trilophodon giganteus*
- 7. *Trilophodon phippsi*
- 6. *Trilophodon* (*Tatabelodon*) *gregorii*
- 5. *Trilophodon* (*Tatabelodon*) *riograndensis*

XII. *Trilophodon, Phiomia*. 'Prod-tuskers'
- 9. *Trilophodon* (*Megabelodon*) *lulli*
- 8. *Trilophodon abeli*
- 7. *Trilophodon pojoaquensis*
- 6. *Trilophodon* (*Genomastodon*) *osborni*
- 5. *Trilophodon cruziensis*
- 4. *Trilophodon fricki*

XIII. *Amebelodon, Phiomia*. 'Shovel-tuskers'
- 8 *Amebelodon fricki*
- 7. *Amebelodon* (*Tril.*) *hicksi*
- 6. *Amebelodon* (*Tril.*) *paladentatus*
- 5. *Phiomia osborni*
- 3. *Phiomia serridens*
- 2. *Phiomia wintoni*
- 1. *Phiomia minor*

XIV. *Tetralophodon*, Eurasia
- 6. *Tetralophodon grandincisivus*
- 5. *Tetralophodon punjabensis*
- 4. *Tetralophodon* (*Lydekkera*) *falconeri*
- 3. *Tetralophodon bumiajuensis*
- 2. *Tetralophodon longirostris*
- 1. *Tetralophodon* (*Lydekkeria*) *sinensis*

XV. *Tetralophodon*, America
- 5. *Tetralophodon* (*Morrillia*) *barbouri*
- 4. *Tetralophodon brazosius*
- 3. *Tetralophodon elegans*
- 2. *Tetralophodon campester*
- 1. *Tetralophodon fricki* sp. nov.

XVI. *Serbelodon, Trobelodon*
- 3. *Serbelodon barnhami*
- 2. *Serbelodon barbourensis*
- 1. *Trobelodon taoensis*

XVII. *Serridentinus* Group
- 8. *Serridentinus guatemalensis*
- 7. *Serridentinus progressus*
- 6. *Serridentinus hasnotensis*
- 5. *Serridentinus productus*
- 4. *Serridentinus gobiensis*
- 3. *Serridentinus metachinjiensis*
- 2. *Serridentinus prochinjiensis*
- 1. *Serridentinus subtaprouleus*

XVIII. *Serridentinus serridens* Group
- 6. *Serridentinus præcursor*
- 5. *Serridentinus cimarronis*
- 4. *Serridentinus angustivallis*
- 3. *Serridentinus serridens*
- 2. *Serridentinus proavus*
- 1. *Serridentinus chinjiensis*

XIX. *Ocalientinus*
- 5. *Ocalientinus* (*Ser.*) *florescens*
- 4. *Ocalientinus* (*Ser.*) *obliquidens*
- 3. *Ocalientinus* (*Ser.*) *floridanus*
- 2. *Ocalientinus* (*Ser.*) *republicanus*
- 1. *Ocalientinus ojocaliensis*

XX. *Serridentinus browni* Group
- 3. *Serridentinus browni*
- 2. *Serridentinus mongoliensis*
- 1. *Serridentinus annectens*

XXI. *Platybelodon*
- 3. *Platybelodon barnumbrowni*
- 2. *Platybelodon grangeri*
- 1. *Platybelodon danovi*

XXII *Pentalophodon*
- 5 *Pentalophodon falconeri* sp. n.
- 4 *Pentalophodon swalenæ*

XXIII *Anancus*
- 4 *Anancus falconeri*
- 3 *Anancus arvernensis*
- 2 *Anancus perimensis*
- 1 *Anancus properimensis* sp. n.

XXIV. *Synconolophus*
- 3. *Synconolophus dhokpathanensis*
- 2. *Synconolophus hasnoti*
- 1. *Synconolophus corrugatus*

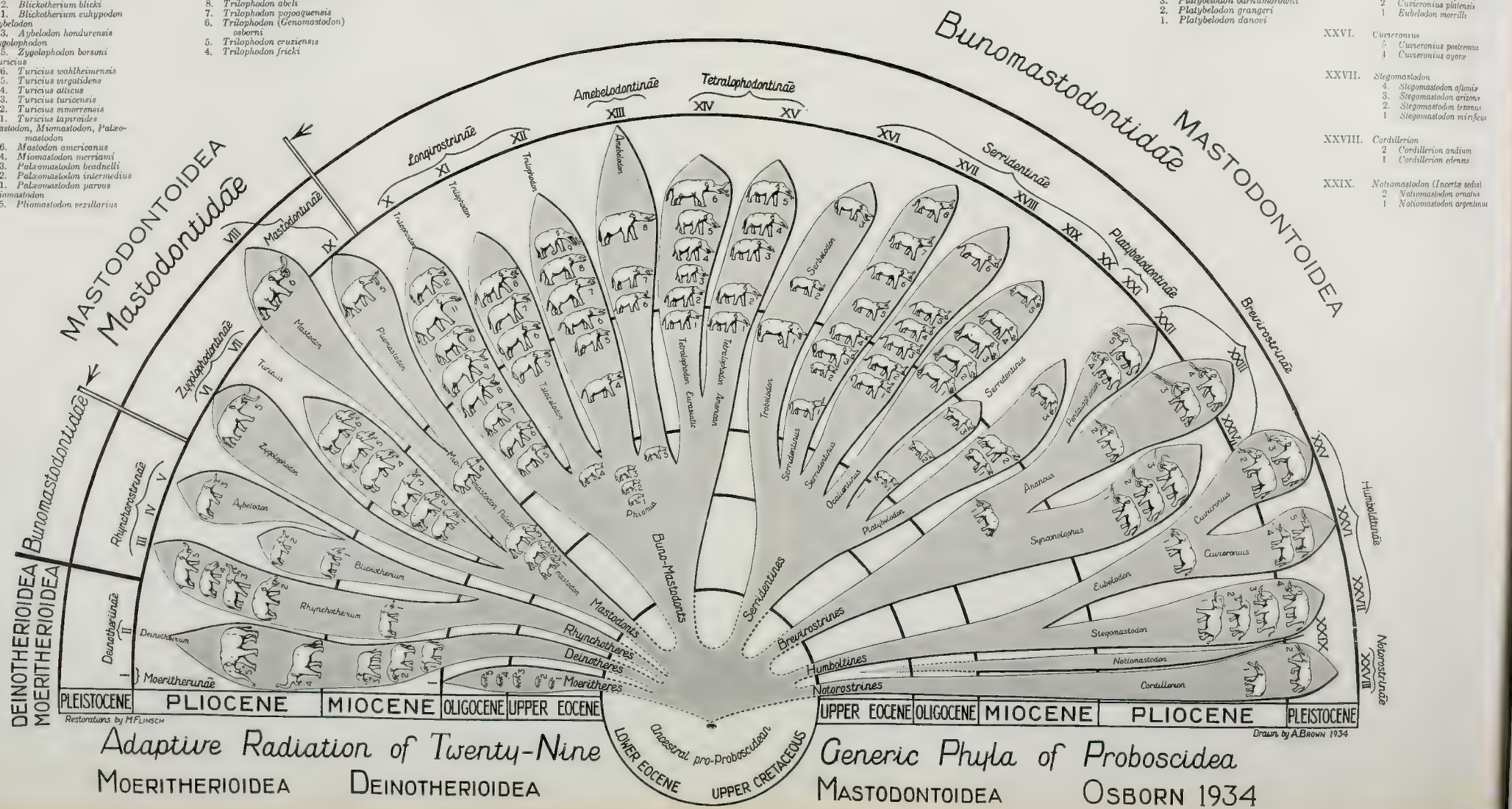
XXV. *Cuvieronius, Eubelodon*
- 3 *Cuvieronius superbus*
- 2 *Cuvieronius platensis*
- 1 *Eubelodon morrilli*

XXVI. *Cuvieronius*
- 5 *Cuvieronius postremus*
- 4 *Cuvieronius ayoræ*

XXVII. *Stegomastodon*
- 4. *Stegomastodon oftonis*
- 3. *Stegomastodon arizonæ*
- 2. *Stegomastodon texanus*
- 1 *Stegomastodon mirificus*

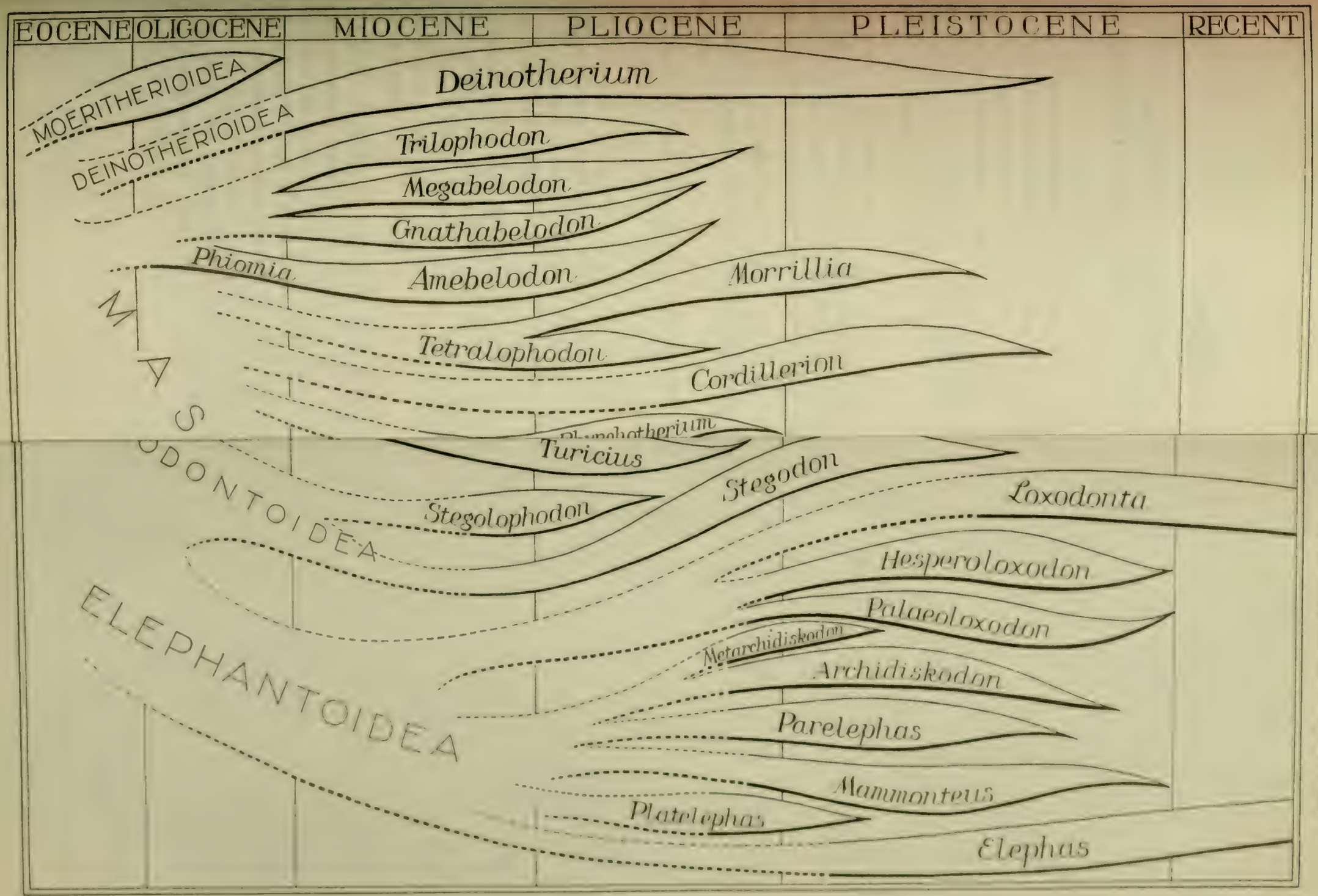
XXVIII. *Cordillerion*
- 2 *Cordillerion andium*
- 1 *Cordillerion edensis*

XXIX. *Notiomastodon* (Incertæ sedis)
- 2 *Notiomastodon ornatus*
- 1 *Notiomastodon argentinus*



Adaptive Radiation of Twenty-Nine Generic Phyla of Proboscidea

MOERITHERIOIDEA DEINOTHERIOIDEA MASTODONTOIDEA OSBORN 1934


EOCENE
OLIGOCENE
MIOCENE
PLIOCENE
PLEISTOCENE
RECENT
MOERITHERIOIDEA
DEINOTHERIOIDEA
Deinotherium
Trilophodon
Megabelodon
Gnathabelodon
Phiomia
Amebelodon
Morrillia
MASTODONTOIDEA
Tetralophodon
Cordillerion
Turicius
Stegodon
Loxodonta
Stegolophodon
Hesperoloxodon
Palaeoloxodon
Metarchidiskodon
Archidiskodon
ELEPHANTOIDEA
Parelephas
Mammonteus
Platelephas
Elephas

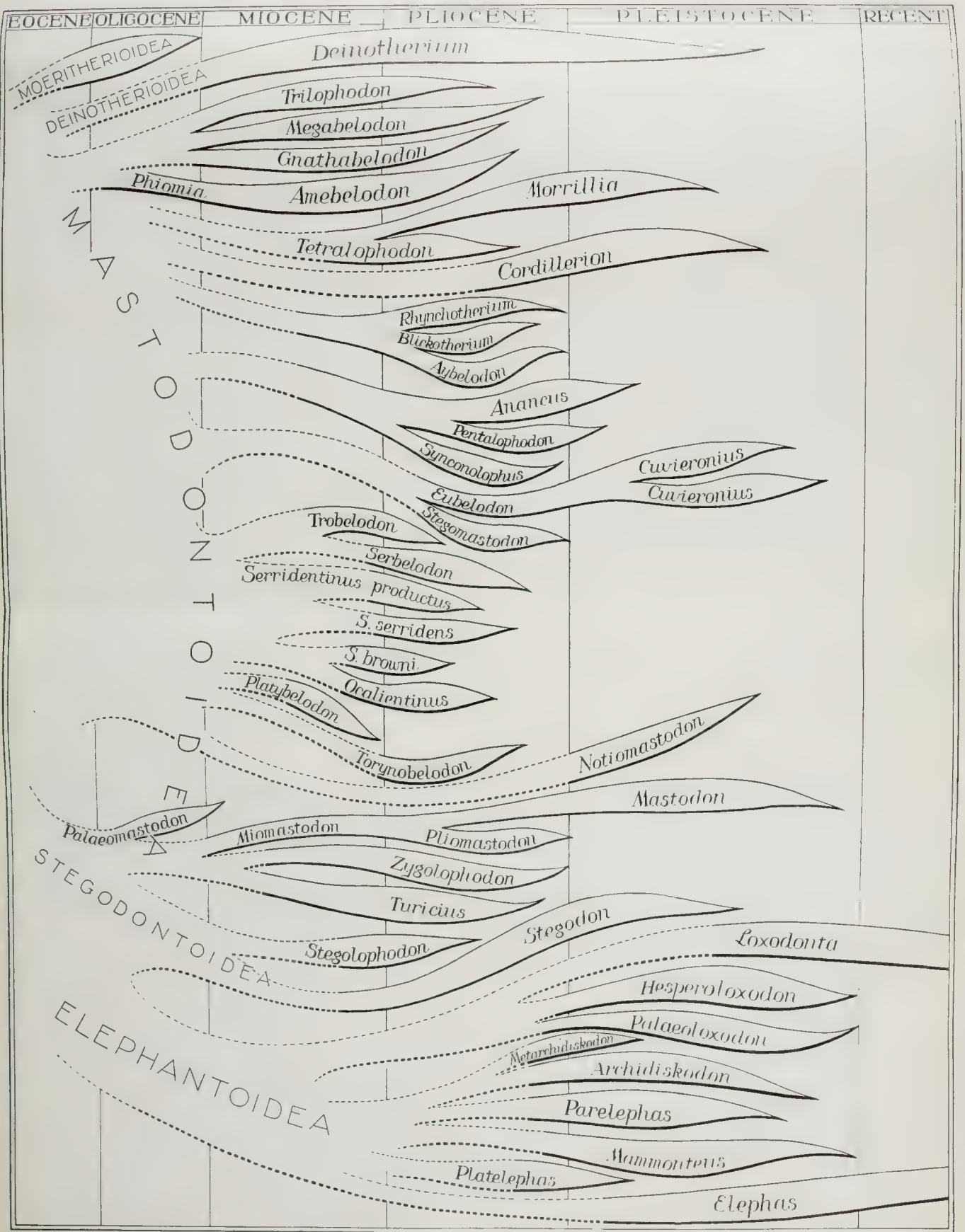


PLATE XI. FINAL DIAGRAM (1935) SHOWING ADAPTIVE RADIATION OF THE FORTY-THREE GENERIC PHYLA OF THE PROBOSCIDEA. COMPARE FIGURES 3, 7, AND 8, ALSO PLATE X OPPOSITE

APPENDIX TO VOLUME I

ADAPTIVE RADIATION OF THE MASTODONTOIDEA AS DISCOVERED AND ANALYZED UP TO AND INCLUDING THE YEAR 1935

SEPARATION OF THE CLASSIC GENUS MASTODON INTO FOUR FAMILIES, FIFTEEN SUBFAMILIES, AND THIRTY-ONE GENERA. GENERIC CLASSIFICATION BY PROGRESSIVE DIVERGENT ADAPTATIONS IN THE GRINDING TEETH AND THE TUSKS. FAMILY CLASSIFICATION BY FUNDAMENTAL PATTERN, PRIMITIVE AND PROGRESSIVE, OF GRINDING TEETH. SUBFAMILY CLASSIFICATION BY ELONGATION OR ABBREVIATION OF THE MANDIBLE AND DIVERGENT ADAPTATIONS OF THE INFERIOR INCISORS. NEW OR INCOMPLETELY DESCRIBED FAMILIES, SUBFAMILIES, GENERA, AND SPECIES TO 1935 INCLUSIVE. FINAL SUMMARY AND CLASSIFICATION OF KNOWN GENERA AND SPECIES IN PHYLOGENETIC ORDER. GEOLOGIC AND FAUNISTIC SUCCESSION OF THE PROBOSCIDEANS IN MIOCENE, PLIOCENE, AND PLEISTOCENE TIMES, WITH CHARTS.

GENERA.—The most revolutionary general result is the adaptive radiation of the genus *Mastodon*, as understood by Cuvier, Darwin, and other eminent zoologists even up to the present time, into *four families embracing fifteen subfamilies, which in turn embrace thirty or more genera*! This astounding expansion of the Cuvier-Darwin genus *Mastodon* is the result of three lines of research and exploration:

First, of our more intensive study and analysis of the classic types of mastodonts reviewed in the British Museum Catalogue of 1886 by Richard Lydekker, the last representative of the old conservative school of palæontologists.

Second, of our more extended knowledge of species and genera known only by their grinding teeth, as analyzed by Hugh Falconer prior to our modern recognition of the all-pervading principles of parallelism and convergence.

Third, of the world-wide and intensive exploration in the continental masses of Africa, Eurasia, and North and South America, leading to the discovery of the Fayûm fauna of Egypt, to new explorations in the Siwaliks of India, to epoch-making discoveries in the central Gobi Desert of Mongolia, to unheralded new proboscideans found in the Miocene to Pleistocene Tertiaries of North America.

A genus like Cuvier's *Mastodon* may long be known by a single species to which in time may be added a Pliocene phase (e. g., *Pliomastodon*) and then a Miocene phase (e. g., *Miomastodon*) with the certainty that an Eocene phase in time will be discovered. Another genus, the shovel-tusker *Amebelodon*, by a prolonged period of research and exploration has been traced back (Pls. v, vi) to its remote but absolutely direct Oligocene ancestor *Phiomia*.

The two classic genera of South America, *Cordillerion* and *Cuvieronius*, were long associated simply because of their occurrence together in the South American continent but are now found to be absolutely distinct, *Cordillerion* tracing its descent to direct ancestors in California, while recent exploration has not only revealed primitive forms of *Cuvieronius* in Ecuador but its more remote ancestor *Eubelodon* in Nebraska. We may be certain that at some future time we may trace this last-named form back to northern or central Asia and ultimately perhaps to Africa. Of Humboldtine family relationship is *Stegomastodon* of which we are still without knowledge concerning its Asiatic and possibly African forbears. Still more isolated is the recently recognized *Notiomastodon*, which is unquestionably related to the Serridentines of Eurasia and widely remote from either the *Cuvieronius* or *Cordillerion* stocks.

The classic *Trilophodon angustidens* of the Middle Miocene of France is now traced to the *Trilophodon angustidens libycus* of North Africa through the very primitive *Trilophodon pontileviensis* of the Lower Miocene of France and *Trilophodon cooperi* of the Lower Miocene of Baluchistan with great progeny of eighteen species in Eurasia and seventeen species in America differentiated into 4–5 subgeneric groups in which the grinding tooth pattern remains relatively the same with parallel evolution and complication of the ridge-crests and divergent adaptations of the inferior incisors. *Trilophodon* is thus the most thoroughly known as to specific differentiation of any genus; given time, each of the subgeneric branches would obtain generic rank. *Trilophodon* is a polyphyletic genus in contrast to such monophyletic genera as *Deinotherium* and *Amebelodon*. A genus, accordingly, may be monophyletic or polyphyletic.

The separation of one genus from another in different subfamilies is an expression of the length of geologic time elapsing since the primitive divergence from a common stock, as, for example, the divergence from the fundamental pattern in the third superior molar of *Gnathabelodon thorpei* as contrasted with a separate divergence from that pattern in the third superior molar of *Megabelodon lulli*. It is the recognition of these varied degrees of more or less wide divergence in one or more organs which forms the basis of the *generic phylogeny* of the Mastodontoidea.

Redefined by closer analysis of classic forms	Due to more extended knowledge of classic forms	Due to discovery of entirely new forms
Mastodon Cuvier	*Miomastodon* Osborn	*Palæomastodon* Andrews
Trilophodon Falconer	*Pliomastodon* Osborn	*Blickotherium* Frick
Tetralophodon Falconer	*Rhynchotherium* Falconer	*Aybelodon* Frick
Zygolophodon Vacek	*Stegomastodon* Pohlig	*Megabelodon* Barbour
Turicius Osborn		*Phiomia* Andrews and Beadnell
Stegolophodon Schlesinger		*Amebelodon* Barbour
Cordillerion Osborn		*Gnathabelodon* Barbour and Sternberg
Anancus Aymard		*Morrillia* Osborn
Pentalophodon Falconer		*Synconolophus* Osborn
Cuvieronius Osborn		*Eubelodon* Barbour
Serridentinus Osborn		*Ocalientinus* Frick
		Trobelodon Frick
		Serbelodon Frick
		Platybelodon Borissiak
		Torynobelodon Barbour
		Notiomastodon Cabrera

Families.—The four families of MASTODONTOIDEA shown in the classifications above and below stand apart very widely; their adaptive radiation probably dates back to Eocene time. Certain generic phyla embraced within them extend far back in the history of the Mastodontoidea, e. g., the adaptive separation of the Mastodontidæ and the Bunomastodontidæ.

The MASTODONTIDÆ, typified by the grinders of *Mastodon*, are transversely crested (lophodont); the four primary cones are transversely extended and divided into conelets (2–4–8–16–32); the valleys remain open; the progressively acute superior and inferior crests interlock for a cutting or chopping action; trefoil spurs are rudimentary or wanting. The Mastodontidæ divide into four subfamilies separated by different stages in the binary fission of the grinders and united by the progressive abbreviation of the mandible terminating in rounded or rodlike lower incisors.

The BUNOMASTODONTIDÆ develop a crushing and grinding molar with valleys progressively closed by 'central conules' and mesotrefoil spurs which invariably spring from the median (meso-) conelets. This is a grinding rather than cutting molar. 'Central conules' are invariably separate in primitive stages (*Phiomia*) and unite as trefoils or multiply by fission. The seven subfamilies of the Bunomastodontidæ are united by similar

primitive molar patterns with 'central conules' and single mesotrefoils which progressively double in final stages. It is thus very difficult to distinguish genera within these subfamilies by the grinding teeth only.

The HUMBOLDTIDÆ are distinguished by extreme complication and plication of single, double, and multiple trefoils; 'central conules' present (*Cuvieronius postremus*); a highly perfected hyperptychodont grinding tooth evolves adapted to a rotary motion in the comminution of food.

The SERRIDENTIDÆ are readily distinguished from the BUNOMASTODONTIDÆ by the fact that the trefoil spurs arise from the ectoconelets in the lower molars and from the entoconelets in the upper molars; thus, as the trefoil spurs become more and more prominent, the adjacent mesoconelet tends to disappear; the crests by binary fission divide into 4–8 conelets; there are no central conules. The center of the valleys remains open. The Serridentidæ include three subfamilies united by this highly distinctive molar pattern, but widely separated by the divergent adaptations of the jaws into such extremely dissimilar forms as the medium-jawed *Serridentinus*, the long-jawed flat-tusker *Platybelodon*, and the short-jawed *Notiomastodon*.

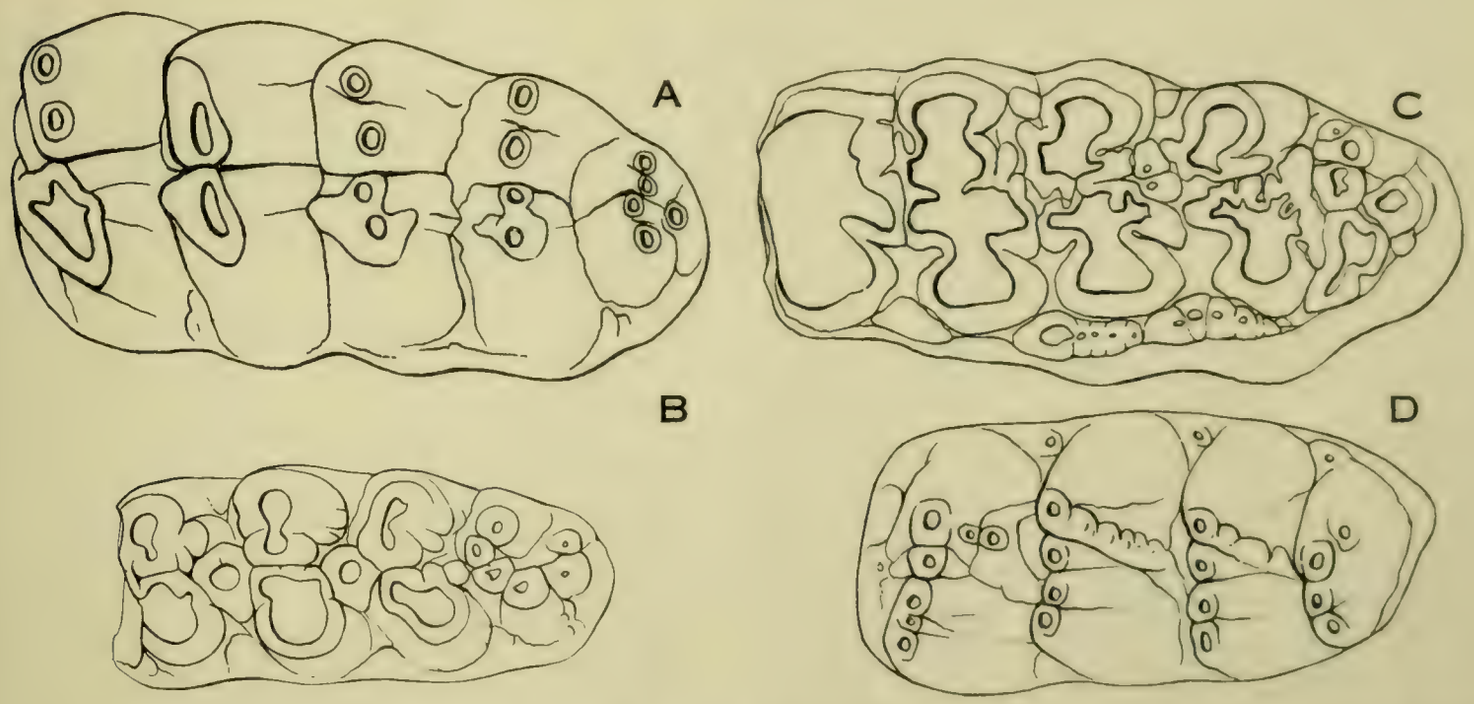


Fig. 652. Molar diagrams showing typical crown pattern of M_3 of each of the four families (geologic range, Oligocene to late Pleistocene) of the Mastodontoidea. All figures reduced to a uniform one-half scale.

MASTODONTIDÆ: A, *Mastodon americanus* ref. (Amer. Mus. 14294), from Fulton, Indiana. Ridge-crests 4½; distinct median sulcus. Pleistocene. See figure 134 B of the present Memoir.

BUNOMASTODONTIDÆ: B, *Trilophodon palæindicus* type (Ind. Mus. A.426; cast Amer. Mus. 9905), from northern Punjab, India. Ridge-crests 4½; prominent central conules. Middle Miocene. See figure 211 of the present Memoir.

HUMBOLDTIDÆ: C, *Cuvieronius superbus* ref. (Buenos Aires Mus. 44; cast Amer. Mus. 27796). Ridge-crests 4½+, double trefoils; highly plicated. Probably Upper Pleistocene. See figure 672 of the present Memoir.

SERRIDENTIDÆ: D, *Serridentinus productus* ref. (Amer. Mus. 10582), from the Clarendon beds of Texas. Ridge-crests 4½; serrated crests or spurs springing from the ectoconelets. Lower Pliocene. See figure 369 C of the present Memoir.

FAMILY CLASSIFICATION OF DEINOTHERES, MŒRITHERES, AND MASTODONTS

MŒRITHERIOIDEA Primitive tetrabunodonts	DEINOTHERIOIDEA Precocious lophodonts	MASTODONTOIDEA All descended from ancestral primitive tetrabunodont molar crowns			
MŒRITHERIIDÆ	CURTOGNATHIDÆ	MASTODONTIDÆ	BUNOMASTODONTIDÆ	HUMBOLDTIDÆ	SERRIDENTIDÆ
Bunolophodont Valleys open. Primitive cones tetrabunodont, sublophodont.	Hyperlophodont Valleys open. Theoretic primitive tetrabunodont ancestral stage.	Lophodont Valleys open. Primitive tetrabunodont stage.	Bunoptychodont Valleys closed by *central conules* and mesotrefoils.	Hyperptychodont Valleys closed by multiple trefoils.	Serrate crested Valleys open, ecto- and entoserrated crests.
	No central conules.	Central conules absent excepting in *Palæomastodon*.	Progressive central conules.'	No central conules.	No central conules.
Primitive stage tetrabunodont, four rounded cones, *M. andrewsi*, *M. gracile*, *M. lyonsi*.	Perfected *transverse* ridge-crests formed out of sixteen+ conelets.	Cones and conelets expanding *transversely* into blunt to sharpened crests.	Cones and mesoconelets expanding *anteroposteriorly* into single or double trefoils.	Cones and conelets expanding *anteroposteriorly* into ptychoid grinding surface.	Cones and conelets expanding *transversely* into blunt or sharpened crests.
Progressive stage, four cones transversely lophoid, *M. trigodon*.	(Lower) ridge-crests *proconcave;* (upper) ridge-crests *postconcave*.	Trefoils rudimentary or absent. Superior and inferior grinders of similar ground-plan.	Superior and inferior molars of reversed ground-plan. Trefoils given off from entomesoconelets in upper molars, from ectomesoconelets in lower molars.	Trefoils given off in pairs from the median conelets, also from the outer conelets, finally ptychoid.	Trefoils given off from *ectoconelets* in lower molars, from *entoconelets* in upper molars. Superior and inferior molars of reversed ground-plan.
Mandibles broadened, abbreviated.	Mandibles decurved.	Mandibles abbreviated, lower tusks reduced.	Mandibles elongated or abbreviated, decurved.	Mandibles abbreviated.	Mandibles moderately elongated.
Mæritherium	*Deinotherium*	*Palæomastodon* (closed sulcus) *Miomastodon* *Pliomastodon* *Mastodon* *Zygolophodon* *Turicius* *Stegolophodon* (open sulcus)	*Phiomia* *Trilophodon* *Megabelodon* *Amebelodon* *Tetralophodon* *Morrillia* (elongated) *Rhynchotherium* *Blickotherium* *Aybelodon* (decurved) *Cordillerion* *Anancus* *Pentalophodon* *Synconolophus* (abbreviated) *Gnathabelodon* (spatulate)	*Eubelodon* *Cuvieronius* *Stegomastodon* (abbreviated)	*Serridentinus* *Ocalientinus* *Platybelodon* *Torynobelodon* *Serbelodon* *Trobelodon* (elongated) *Notiomastodon* (abbreviated)

SUBFAMILIES. Within the four families as herein defined the fifteen subfamilies are distinguished by: (1) Divergent or parallel adaptations of the incisive tusks correlated with the lengthening, broadening, or shortening of the jaw; (2) divergent adaptations of the molar crowns to cutting, crushing, or grinding functions; (3) more or less progressive evolution of similar adaptations in the grinding teeth, e.g., ecto- and entotrefoils in the SERRIDENTIDÆ.

Accordingly the fifteen subfamilies are clearly distinguishable as follows:

SUBORDER	FAMILIES	SUBFAMILIES
MASTODONTOIDEA = genus '*Mastodon*' of Cuvier and Darwin	MASTODONTIDÆ Lophodont, binary fission of cones into conelets. Molars cutting.	1. PALÆOMASTODONTINÆ, proto-mastodont, medium jawed, molars hexabunodont, closing sulcus. Lower incisors rounded, ?rodlike. Three cones on each crest. 2. MASTODONTINÆ, typical mastodonts, short jawed, molar crowns with median sulcus. Lower incisors reduced, rodlike. Four conelets on each crest. 3. ZYGOLOPHODONTINÆ, sharply lophodont, sulcus disappearing, conelets numerous. Lower incisors rounded, rodlike. Four to twenty-five conelets on each crest. 4. STEGOLOPHODONTINÆ, molars sub-stegodont, multiple rounded conelets, connate at base. Lower incisors undiscovered.
	BUNOMASTODONTIDÆ Bunoptychodont. 'Central conules' and mesotrefoil spurs. Molars progressively crushing.	5. RHYNCHOROSTRINÆ, jaws relatively abbreviated, beaked. Incisive tusks upturned, with enamel. Molars narrow. 6. LONGIROSTRINÆ, extremely long jawed, incisive tusks rounded, oval or laterally compressed. 7. GNATHABELODONTINÆ, broad, tuskless mandibular symphysis. Lower incisors absent. Molars very broad. 8. AMEBELODONTINÆ, typical shovel-tuskers. Incisive tusks elongate, flattened, and dominant. Molars narrow. 9. TETRALOPHODONTINÆ, jaws elongated, four crested 'intermediate molars,' Dp 4, M 1, M 2. 10. NOTOROSTRINÆ, short jawed, lower incisors wanting; enamel band in subspiral curve. Molars narrow. 11. BREVIROSTRINÆ, short jawed, lower incisors wanting. Molars narrow.
	HUMBOLDTIDÆ Hyperptychodont. Molars grinding.	12. HUMBOLDTINÆ, jaws abbreviated, tuskless. Superior incisors rounded, upcurved.
	SERRIDENTIDÆ Serrate-crested by ectoconelet spurs.	13. SERRIDENTINÆ, jaws elongated, incisors oval. Molars with outer and inner cutting crest spurs. 14. PLATYBELODONTINÆ, typical flat-tuskers. Lower incisive tusks greatly broadened and flattened with central rod-cones. 15. NOTIOMASTODONTINÆ, short jawed, inferior incisors wanting, superior incisors down- and out-turned with broad enamel band. Inferior molars with prominent serrated ridges.

GENUS: MASTODON OF CUVIER AND DARWIN MASTODONTOIDEA OF THIS MEMOIR

PHYLOGENETIC REGROUPING OF THE MASTODONTOIDEA INTO FOUR FAMILIES, FIFTEEN SUBFAMILIES, AND THIRTY-ONE GENERA

SUBORDER: MASTODONTOIDEA

I. FAM.: MASTODONTIDÆ, 'lophodont mastodonts' of Eurasia and North America.

SUBFAM.: PALÆOMASTODONTINÆ, 'proto-mastodonts' of North Africa.

GENUS: *Palæomastodon*, 'ancient mastodon' of North Africa, Eocene-Oligocene.

SUBFAM.: MASTODONTINÆ, 'typical mastodontines' of Eurasia and North America.

GENERA: *Miomastodon*, 'Miocene mastodon' of Eurasia and North America.
Pliomastodon, 'Pliocene mastodon' of Eurasia and North America.
Mastodon, 'typical mastodon' of Eurasiatic and North American forests.

SUBFAM.: ZYGOLOPHODONTINÆ, 'yoke-crested mastodonts' of Eurasia, not reaching North America.

GENERA: *Zygolophodon*, typical 'yoke-crested mastodont' of Eurasiatic Miocene to Pleistocene.
Turicius, sharp-crested 'Zurich mastodont' of the European Miocene and Pliocene.

SUBFAM.: STEGOLOPHODONTINÆ, 'pro-stegodonts' of eastern and southern Eurasia.

GENUS: *Stegolophodon*, 'roof-crested pro-stegodont' parallel and collateral in evolution with the true *Stegodon* of eastern and southern Eurasia.

II. FAM.: BUNOMASTODONTIDÆ, 'cone-crested bunomastodonts' of Africa, Eurasia, and North and South America.

SUBFAM.: RHYNCHOROSTRINÆ, 'beak-jawed mastodonts' of North Africa, India, North and Central America.

GENERA: *Rhynchotherium*, typical 'beak-jawed rhynchorostrine' of Falconer. Western North America: Oregon to Mexico.
Blickotherium, 'slender-jawed rhynchorostrine' of Nebraska, Mexico, and Honduras.
Aybelodon, 'slender-tusked (enamel-less) rhynchorostrine' of Honduras.

SUBFAM.: LONGIROSTRINÆ, 'long-jawed bunomastodonts' of Eurasia and North America.

GENERA: *Trilophodon*, 'three-crested longirostrine' of Eurasia and North America.
Megabelodon, 'slender-jawed hyperlongirostrine.'

SUBFAM.: GNATHABELODONTINÆ, 'shovel-jawed longirostrines' of Barbour and Sternberg.

GENUS: *Gnathabelodon*, typical 'shovel-jawed longirostrine' of Barbour and Sternberg.

SUBFAM.: AMEBELODONTINÆ, typical 'shovel-tuskers' of North Africa and central United States.

GENERA: *Phiomia*, ancestral 'Fayûm shovel-tusker' of North Africa.
Amebelodon, typical 'shovel-tusker' of Nebraska.

SUBFAM.: TETRALOPHODONTINÆ, 'four-crested medilongirostrines' of Falconer.

GENERA: *Tetralophodon*, typical 'four-crested medilongirostrine' of Falconer.
Morrillia, 'four-crested medilongirostrine' of the Nebraskan Pleistocene.

SUBFAM.: NOTOROSTRINÆ, typical 'Andean notorostrines' of southern United States and South America.

GENUS: *Cordillerion*, Cuvier's 'Andean mastodon' of the Cordilleras.

SUBFAM.: BREVIROSTRINÆ, Aymard's 'short-jawed brevirostrines' of Eurasia.

GENERA: *Anancus*, 'straight-tusked brevirostrine' of southern Eurasia.
Pentalophodon, Falconer's 'five-crested straight-tusker' of the Siwaliks.
Synconolophus, Osborn's 'syncone-crested brevirostrine' of the Siwaliks.

III. Fam.: HUMBOLDTIDÆ, 'Humboldtine mastodonts' of southern United States and South America.

Subfam.: Humboldtinæ, 'hyperptychoid Humboldtine mastodonts' of southern United States and South America.

Genera: *Eubelodon*, Barbour's 'ancestral Humboldtine mastodont' of Nebraska.

Cuvieronius, typical 'Humboldtine mastodont' of the Pampean and Andean regions of South America.

Stegomastodon, Pohlig's 'roof-toothed Humboldtine mastodont' of the southwestern United States.

IV. Fam.: SERRIDENTIDÆ, 'serrate-crested medilongirostrines' of Eurasia, North and South America.

Subfam.: Serridentinæ, 'serrate-crested serridentines' of North and South America.

Genera: *Serridentinus*, typical 'serrate-toothed serridentine' of Eurasia and North America.

Ocalientinus, Frick's 'multiserrate-crested serridentine' of the United States and Mongolia.

Serbelodon, Frick's 'sub-shovel-tusked serridentine' of New Mexico.

Trobelodon, Frick's 'brevidentate serridentine' of New Mexico.

Subfam.: Platybelodontinæ, Borissiak's 'flat-tusked serridentine' of Eurasia and North America.

Genera: *Platybelodon*, Borissiak's typical 'flat-tusker' of Mongolia.

Torynobelodon, Barbour's 'dredge-tusker' of Nebraska.

Subfam.: Notiomastodontinæ, 'short-jawed serridentines' of South America.

Genus: *Notiomastodon*, Cabrera's 'short-jawed serridentine' of the Pampean.

NEW SUBFAMILIES, GENERA, AND SPECIES

In course of the text of Volume I several new terms are introduced without definition; these may now be defined.

Family: MASTODONTIDÆ Girard, 1852

Andrews placed *Palæomastodon* in a new family, Palæomastodontidæ. Matsumoto went to an opposite extreme in considering *Palæomastodon* the direct ancestor of *Mastodon*. Osborn (present Vol. I, p. 143) removes it from the Mastodontinæ and places it in a separate subfamily Palæomastodontinæ, defined as follows:

PALÆOMASTODONTINÆ subfam. nov.

(1) Typified by three ascending species (*Palæomastodon parvus*, *P. intermedius*, *P. beadnelli*) progressive in size and in evolution of molars from tetrabunodont cones (*P. parvus*) to hexabunodont cones (*P. intermedius* and *P. beadnelli*). (2) Mandibular symphysis relatively short as compared with *Phiomia* (Fig. 90, p. 142). (3) Inferior incisive tusks rounded and relatively abbreviated as compared with flattened, elongated incisive tusks of *Phiomia*. (4) Molars exhibiting central conules; trefoils rudimentary or absent; transversely bunolophoid,

transverse valleys sharply defined as in the Mastodontinæ. (5) Proportions relatively broad, of bunolophodont rather than of bunomastodont type. (6) Intermediate *proto-* and *metaconules* progressively developing (Fig. 93, p. 145) to perfect the transverse crests, thus closing the median longitudinal *sulcus* which is characteristic of all the Mastodontinæ (Pl. 1, pp. 134–135). (7) Habits probably forest loving with transversely secant molar crests for cutting herbage rather than with river- and swamp-loving adaptations of *Phiomia*.

NEW MASTODONTINÆ

Despite the extreme rarity of the remains of forest-loving and browsing mastodonts, exemplified by the rarity of *Palæomastodon* as compared with *Phiomia* in the Fayûm deposits, several discoveries of isolated grinding teeth have been made in the Tertiary deposits of Europe and North America which are now recognized as belonging to successors of still unknown true Mastodontinæ of Africa and ancestors of the true Mastodontinæ of North America. These most welcome stages in the great phylogenetic tree of the Mastodontoidea include the following in order of succession:

Miomastodon depereti sp. nov., extremely primitive, Lower Miocene Sables de l'Orléanais, France, represented by a single third superior molar, four crested.

Miomastodon merriami Osborn, 1921, Humboldt Co., Nevada, somewhat more progressive than *M. depereti* (see p. 154).

Miomastodon tapiroides americanus Schlesinger, 1922, with intermediate grinding structure between *Miomastodon depereti* and *M. merriami* (see p. 156).

Pliomastodon sellardsi Simpson, 1930, Brewster, Polk Co., Florida, represented by an inferior mandible (see p. 160).

Pliomastodon americanus praetypica Schlesinger, 1919, 1922, Middle Pliocene of Hungary and Austria, represented by a number of superior and inferior molars (see p. 159).

Pliomastodon vexillarius Matthew, 1930, Fresno Co., California (see p. 161).

Mastodon pavlowi sp. nov., Podolia, Russia, represented by superior and inferior molars.

Mastodon grangeri Barbour, 1934, Thurston Co., Nebraska, Pleistocene of North America, distinguished by very long, straight superior tusks.

Mastodon acutidens sp. nov., Pleistocene of Rochester, Indiana, distinguished by the extremely acute or sharpened transverse crests.

Each of the above generic and specific stages may be distinguished (1) by the progressive simplification of the superior tusks in the loss of the enamel band and (2) by the progressive complication of the grinding teeth through binary fission of the cones into conelets and the addition of a small tetartoloph to the superior molars and a small pentalophid to the inferior molars. Further monographic research on these very rare molars of the true Mastodontinæ of western Eurasia will doubtless reveal an orderly succession of stages in the binary fission of the cones into conelets.

DESCRIPTION OF NEW SPECIES OF MASTODONTINÆ

Miomastodon depereti sp. nov.

Figures 138, 230, and 653, also Pl. I, B

TYPE.—Third superior molar of the left side, l.M³, in the Paris Museum. HORIZON AND LOCALITY.—Lower Miocene of Chevilly, Sables de l'Orléanais, France. TYPE FIGURE.—Mayet, 1908, Pl. VII, fig. 3. See Osborn's figure 138A (p. 196), also Plate I, B (between pp. 134–135), figure 230D[1] (p. 284), and figure 653 herewith. TYPE DESCRIPTION.—This type left third superior molar, l.M³, is designated by Mayet (1908) in the legend of his Pl. VII, fig. 3, as follows: "3.—*Mastodon angustidens*. Chevilly (sablière Cassegrain, au Glorieux, août 1877). Dernière molaire supérieure gauche. Paris, Muséum. Grandeur naturelle." Its measurements are: 129 mm. x 65 mm. Mayet (1908) regarded it as referable to *Mastodon* [=*Trilophodon*] *angustidens*.

OSBORN'S OBSERVATIONS, 1935.—Osborn observes that this type tooth (1) entirely lacks the distinctive bunomastodont characters of *Trilophodon*, namely, *the central conules and trefoils*, (2) that it corresponds with a third left superior molar, l.M³, of one of the true Mastodontinæ. In honor of the late Charles Depéret, the name *Miomastodon depereti* may be applied. (3) As depicted in Osborn's new type figure (Pl. I, B) this four-crested molar corresponds in the structure of its cones and conelets with a theoretic ancestral stage of the true *Mastodon americanus;* (4) the nearest resemblance to this stage is that of the *Miomastodon merriami* type (Figs. 89 and 98B, also Fig. 653 herewith) of the Middle Miocene of Nevada, alike distinguished by retarded fission of cones and conelets in proto- and metalophids, and progressive fission in trito- and tetartolophids into four conelets. (5) Thus the *Miomastodon depereti* type molar from the Lower Miocene Burdigalian of France appears directly ancestral to the Middle Miocene *Miomastodon merriami* of the Virgin Valley horizon of Nevada. (6) The *Miomastodon depereti* type l.M³ (Pl. I, B) exhibits only *fourteen* cones and conelets; the more progressive *Pliomastodon praetypica* of the Pliocene of Hungary (Pl. I, C, D, H) exhibits *sixteen* conelets in the third superior molars and *nineteen* conelets in the 4½ crested third inferior molars.

SPECIFIC CHARACTERS.—(1) Third superior molars with internal and external cones separated by deep longitudinal median sulcus; (2) transverse valleys widely open by *absence of 'central conules'* which are very conspicuous in the contemporary Lower Miocene molars of *Trilophodon pontileviensis* (Fig. 230, A, B, C, p. 284); (3) protoloph consisting of two large undivided cones, metaloph consisting of one external cone and two internal conelets, trito- and tetartolophs consisting of four conelets, tetartoloph very narrow, pentaloph a rudimentary talon in comparison with type and referred *Pliomastodon praetypica* (see Pl. I, C and H, pp. 134–135) in which a rudimentary pentaloph exhibits three to five conelets; also in comparison with *Mastodon pavlowi* type M³ (Pl. I,

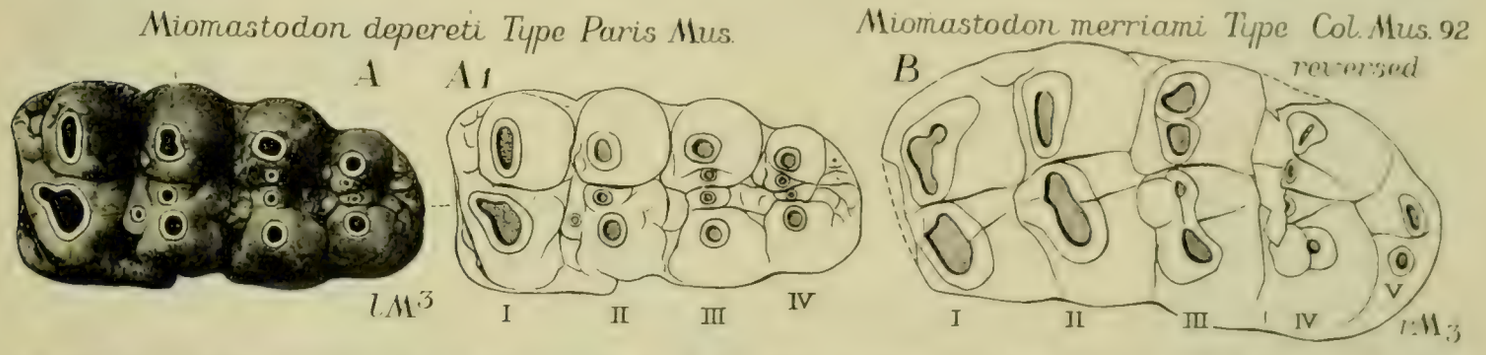


Fig. 653. Types of *Miomastodon depereti*, Lower Miocene of Chevilly, Sables de l'Orléanais, France, and *Miomastodon merriami*, Middle Miocene of Nevada, Virgin Valley formation. All figures seven-sixteenths natural size.

A, Type of *Miomastodon depereti*, l.M³, retouched, after Mayet, 1908, Pl. VII, fig. 3.

A 1, Diagram of the same, exhibiting four ridge-crests and a talon, containing altogether fourteen oval or rounded cones and conelets divided by median sulcus.

B, Type of *Miomastodon merriami*, r.M₃ (Colo. Mus. 92), *reversed*, exhibiting 4–5 ridge-crests, the latter displaying two cones, altogether eighteen conelets. Compare Fig. 89, p. 141, this Memoir.

I) in which the pentaloph exhibits five conelets. (4) The Miocene *Miomastodon depereti* type stage is tetralophoid with rudimentary pentaloph, very primitive, in comparison with the Pliocene *Pliomastodon praetypica* and the Pleistocene *Mastodon pavlowi*.

COMPARISON OF MIOMASTODON DEPERETI AND M. MERRIAMI TYPES.—*Miomastodon merriami* is more progressive than *M. depereti* in the presence of the following characters: (1) Two cones on the tetartolophid; (2) the slightly more advanced binary fission in the proto- and metalophids; (3) the decidedly more progressive binary fission of the trito- and tetartolophids; (4) the four lophs are more sharp and prominent. In brief, the type of *M. merriami* of Colorado confirms our reference of *M. depereti* to the Mastodontinæ, and exhibits a stage in the direction of *Pliomastodon* and *Mastodon* in which the binary fission of each crest into four conelets is consummated.

[1] *Miomastodon depereti* type is erroneously given as an l.M₃ in the legend to this illustration.

Generically *Miomastodon depereti* of the Lower Miocene is distinguished from the contemporary *Zygolophodon pyrenaicus* (Pl. II, B) by (a) the depth of the median sulcus, by (b) the retarded aristogenesis of the conelets. Thus:

Genus: *Miomastodon*

1. Retarded binary fission of cones and conelets in proto- and metalophs.
2. Conelets never exceeding four in each loph or transverse ridge-crest.
3. Persistence of deep median sulcus.

Genus: *Zygolophodon*

1. Accelerated binary fission of cones and conelets.
2. Four primitive conelets in each transverse ridge-crest, progressive from four to six in each crest.
3. Disappearance of deep median sulcus.

Generic Stages.—The characters of the generic and specific stages of *Miomastodon* and *Pliomastodon*, as defined and distinguished in Chapter VI (pp. 138–142, 150–164), as well as the Eurasiatic species of *Mastodon pavlowi*, may now be clarified and amplified in ascending geologic order, as follows:

RETARDED BINARY FISSION OF CONES INTO CONELETS IN THE MASTODONTINÆ (SEE PLATE I)

Pleistocene	*Mastodon acutidens* sp. nov. Second and third superior molars, second and third inferior molars: Binary fission incipient; each main cone tends to be doubly divided, but this is obscured by the secondary production of numerous conelets of varying numbers.
Pleistocene of Central Eurasia	*Mastodon pavlowi* sp. nov., Pestchana, Podolia, Russia. Second superior molar trilophoid with nine conelets; binary fission incomplete. Third superior molar pentalophoid with twenty-one conelets; binary fission complete. Third inferior molar with twenty-five conelets (pentalophoid); binary fission complete.
Pliocene of Hungary and Austria	*Pliomastodon praetypica* Schlesinger, 1922, Hungary and Austria. Second superior molar trilophoid with twelve conelets; binary fission complete. Third superior molar pentalophoid with sixteen conelets in the four anterior crests and an indeterminate number in the pentaloph; binary fission complete. Second inferior molar trilophoid with twelve conelets; binary fission complete. Third inferior molar pentalophoid with nineteen conelets; binary fission complete.
Lower Miocene of France	*Miomastodon depereti* sp. nov. Third superior molar tetralophoid (pentaloph a rudimentary talon) with fourteen cones and conelets; binary fission incipient.

Mastodon pavlowi sp. nov.

Figure 654, also Pl. I, G and I,

Type.—First, second, and third superior molars of the right side *in situ*, r.M^{1-3}, second and third superior molars and third inferior molar of the left side, l.M^{2-3}, l.M_3. Geological Cabinet of the University of Moscow. Horizon and Locality.—Pestchana, Podolia, Russia. Pleistocene. Type Figure.—Pavlow, 1894.1, Pl. I, figs. 1, 2, and 3 (see Pl. I, G and I, also Fig. 654 of the present Memoir).

It is a pleasure to dedicate to the eminent Russian palæontologist, Dr. Marie Pavlow, the Pleistocene stage of the Russian *Mastodon* which in her admirable memoir of 1894 "Les Mastodontes de la Russie et leurs Rapports avec les Mastodontes des Autres Pays," she referred to *Mastodon ohioticus* with the following description and measurements (*op. cit.*, pp. 8–12):

"*Mastodon Ohioticus* Cuv. Pl. I. Pl. II, fig. 2. Ce qu'il y a de plus précieux dans ces restes fossiles de *Mastodon* envoyés en partie par Mr. Obleoukhow et apportés par Mr. Kislakovsky du gouvernement de *Kamenez-Podolsk*, district de Balta, village Pestchana, c'est, sauf leur position géologique bien determinée, leur appartenance incontestable au même individu. Ils sont représentés par la dentition presque complète des mâchoires supérieures et inférieures, sauf les défenses qui manquent, et par quelques os du squelette."

"Les *trois molaires supérieures droites* (Pl. I, fig. 1) se trouvent en place dans la mâchoire et nous donnent ainsi la possibilité d'être sûrs de leur position naturelle chez l'animal vivant. Elles nous permettent d'un autre côté de ranger les dents isolées de la

Type superior molars of mastodon pavlowi sp. nov.

Fig. 654. First, second, and third superior molars of the right side, r.M^{1-3}, of "*Mastodon ohioticus* Cuv." Pestchana, Podolia, Russia. After Pavlow, 1894, Pl. I, fig. 1. Geological Cabinet of the University of Moscow. Four-thirteenths natural size.

mâchoire gauche dans l'ordre, correspondant à celui du côté droit."

"La mâchoire supérieure droite, renfermant les trois molaires, est longue de 37 cm. sur son côté externe arrondi, renfermant les dents; sa partie supérieure est cassée."

"La m^2 *supérieure droite* (f. 1, m^2) longue de 110 mm. (vers le milieu), large de 85 mm."

"La m^3 *supérieure droite* (f. 1, m^3) longue de 150 mm., large de 90 mm. (2e crête) est formée de quatre crêtes et d'un talon postérieur bien développé, ayant déjà l'aspect d'une petite 5ème crête."

We select as type the admirably preserved first, second, and third superior molars and inferior molar belonging to the same individual (superior molars, *op. cit.*, Pl. I, figs. 1 and 2; inferior molar, Pl. I, fig. 3). The coronal elements in these superior and inferior molars are carefully diagnosed in Osborn's Plate I (pp. 134-135, this Memoir), I (l.M^{2-3}), G (l.M_3); see also figure 654 (r.M $^{1-3}$).

Mastodon grangeri Barbour, 1934

Figure 655

Mastodon grangeri Barbour, 1934. "The Thurston County Mastodon, Mastodon grangeri, sp. nov." Neb. State Mus., Bull. 35, I, May, pp. 287–290, text fig. 170. TYPE.—Skull and tusks. Morrill Palæontological Collections, Neb. Mus. 8-9-00. HORIZON AND LOCALITY.—Pleistocene gravel, II Glacial Epoch. Pender, Thurston County, Nebraska. TYPE FIGURE.—*Op. cit.*, p. 289, fig. 170. See also figure 655 of the present Memoir.

TYPE DESCRIPTION.—(Barbour, 1934.1, pp. 287–290): "The Thurston County mastodon seems to represent a Plains type which differs from the ordinary forest type of *Mastodon americanus* and seems to be a distinct species. We are naming this specimen *Mastodon grangeri* in recognition of Dr. Walter Granger who has so furthered the cause of vertebrate palaeontology . . . Unlike typical forms, the tusks are long, slim, almost straight, curving but slightly and spreading but little at the tips. The length of each tusk is about nine feet, and the diameter five inches . . . Contrary to rule all three molars are present on each side and are perfectly preserved . . . Molar one is worn and well cupped, in molar two the first grinding ridge is well worn, while molar three shows little wear, and cement is wanting. The tusks and the teeth indicate a mature but not aged individual. The teeth of *Mastodon grangeri*, compared with those of *Mastodon americanus*, seem narrow and relatively small even after making due allowance for wide variations in size . . . The third molar has four coarse grinding ridges and a heel, a condition prevailing in other specimens referred to this species . . . The tusks of *Mastodon grangeri* seem to be distinctive, possibly determinative. *Mastodon americanus* as exemplified by the Warren skeleton with its relatively short tusks, curving upward and outward, seems typical of the forest ranging mastodons."

Fig. 655. Type of *Mastodon grangeri* Barbour, 1934, Neb. State Museum, Morrill Palaeontological Collections, 8-9-00. Pleistocene gravels of II Glacial epoch, Pender, Thurston County, Nebraska. Cranium mostly restored in plaster, tusks almost straight, 9 feet (2744 mm.) long, 5 inches (128 mm.) in diameter. A supposed *plains* type of *Mastodon*. After Barbour, 1934.1, fig. 170, p. 289. Scale of left hand illustration one twenty-fourth natural size.

SPECIFIC CHARACTERS.—The characters are as follows: (1) Persistent median sulcus (as distinguished from *Zygolophodon*); (2) each crest in superior molars composed of four conelets in M^3, of three conelets in M^2. (3) In the third inferior molar the cones of the outer side are normally fissioned into two conelets; the cones of the inner side are irregularly fissured into 2–3–4 conelets; total conelets 25. (4) Compared with *Pliomastodon praetypica* (Pl. I, C, D, E, this Memoir), *Mastodon pavlowi* is somewhat more complex in the binary internal fission of the inferior molars. (5) Compared with *Mastodon americanus* (Pl. I, K, J), the conelets are rounded (bunoid) rather than crested (lophoid).

Osborn, 1935: This new stage, *Mastodon pavlowi*, is far more progressive than the Lower Miocene *Miomastodon depereti* (Pl. I, B, this Memoir) in which the pentaloph is rudimentary; it is somewhat more progressive than *Pliomastodon praetypica* (Pl. I, C, D); it is somewhat less progressive than the typical *Mastodon americanus* (Pl. I, K, J), and it is far less progressive than the sharp-crested *M. acutidens* (Pl. I, L).

REFERRED SPECIMENS.—"It is believed that several examples [of *M. grangeri*] are represented in the State Museum. [1] The Boyd County skull, No. 8–8–23, consisting of the palate with

MEASUREMENTS (COMPARE BARBOUR, 1934.1, PP. 288, 290)

Mastodon grangeri
Pender, Thurston County, Nebraska.
Neb. Mus. 8-9-00.

Tusk: length about 9 feet, diameter 5 inches
Palate, width between molars, No. 1, 3¾ inches (94 mm.)
Palate, width between molars, No. 3, 3⅛ inches (79 mm.)

Molar 1, length 3¼ inches (82 mm.)
width 3 inches (76 mm.)

Molar 2, length 4½ inches (114 mm.)
width 3⅜ inches (85 mm.)

Molar 3, length 6⅜ inches (162 mm.)
width 3⅜ inches (85 mm.)
height 2¾ inches (70 mm.)

Mastodon americanus
1½ miles east of Talmadge, Otoe County, Nebraska.
Neb. Mus. 2-6-34.

Tusk: length on outer curve, 7 feet
width at middle, 7¼ inches
width at broken tip, 6⅛ inches
width at base, 8¼ inches
length when restored, 9 to 10 feet

Molar 2, length, 5 inches (126 mm.)
width, 3⅝ inches (92 mm.)
height, 2¼ inches (57 mm.)

Molar 3, length, 8 inches (203 mm.)
width, 4 inches (102 mm.)
height, 2¾ inches (70 mm.)

grinders complete, stumps of tusks, and the basi-cranial elements, has been prepared as a panel mount, and is referred to *Mastodon grangeri*. [2] In this connection must be mentioned the Lancaster County skeleton which was partly exposed by Mr. Arthur Dobson, Class of 1911, which is apparently complete. This specimen lies 15 feet deep in loess near Sheridan Boulevard and the entrance to Memorial Park, Lincoln. As far as explored the bones are in a state of extraordinary preservation, and their excavation will be undertaken, if possible, in the collecting season of 1934. Here again the tusks, where exposed, are as slim and straight as they are in *Mastodon grangeri*, to which we are referring it. [3] In addition there are certain stray tusks showing the slim straight characteristics of *Mastodon grangeri*, but none showing the characteristics of the forest mastodon."

Mastodon acutidens sp. nov.
Figures 131, 135, and 656, also Pl. 1, L

TYPE.—Immature male skull and jaws, with Dp 4–M 3 (M 3 buried in skull and jaw). Amer. Mus. 17727, purchased from E. C. Swabey, 1922. HORIZON AND LOCALITY.— Rochester, Indiana. Pleistocene, Postglacial (IV). TYPE FIGURES.— Figures 131 A1–A4 and 135, also Pl. 1, L, and figure 656 of the present Memoir.

TYPE DESCRIPTION.—(See pp. 185, 189 of the present Memoir) "The immature male skull [Footnote: 'This specimen is now made the type of *Mastodon acutidens*'. . .] (Amer. Mus. 17727, Fig. 131 A1), from Rochester, Indiana, represents a stage in which the three 'intermediate molars' only are in use, namely, Dp 4, M 1, M 2. All these teeth show the three transverse crests characteristic

Fig. 656. Type of *Mastodon acutidens* (Amer. Mus. 17727) from Rochester, Indiana, juvenile male. The most progressive molar stage thus far discovered in America. Compare Fig. 135, p. 189, and Fig. 131, p. 186, this Memoir.

Juvenile cranium (1/16th scale) with open sutures exhibiting deciduous fourth molar, Dp 4, three crested first and second grinders, r.M1, r.M2, third grinders completely buried in the skull and jaw. [The teeth are incorrectly lettered on the jaw in this illustration.—Editor.]

Third left superior molar exhibiting five sharpened and closely appressed ridge-crests (I–V) crowned with multiple fine conelets divided by profound median sulcus (S–S), also prominent sharp entotrefoil spurs (En. tr.). Third left inferior molar, four sharpened ridge-crests (I–IV), the fifth (V) uncalcified, median sulcus (S–S) strongly indicated, sharp ectotrefoil spurs (Ec. tr.).

of this genus and species. The tetralophodont third superior and inferior molars, M^3-M_3, have been extracted from the skull and jaws and are represented in figure 135. In this young male cranium .... (Amer. Mus. 17727) we observe the following points: (1) The facial and cranial portions are subequal in length; (2) the sides of the cranium are nearly parallel; (3) the juvenile tusks are imbedded in slightly expanded premaxillary sockets; (4) all the crests of the grinding teeth (Fig. 131 A1, also Fig. 135) are extremely sharp, representing a high degree of subhypsodonty."

"Immature and Mature Grinding Teeth.—The immature male skull....from Rochester, Indiana (Amer. Mus. 17727, Fig. 131 A1) yields a series of immature dental crests (represented in Fig. 135) of the third left superior molar, l.M^3, and of the third left inferior molar, l.M_3. These ridge-crests are a revelation of the very sharp, almost knife-like summits of the molar ridge-crests, which give a truly *subhypsodont* character to these crowns. These sharply crested summits illustrate the very marked progression of *Mastodon acutidens* sp. nov. upon the low, compressed crowns in the two species *Miomastodon merriami* and *Pliomastodon matthewi*, and upon the rounded lobes, i. e., cones, in *Palæomastodon*."

The third superior and inferior grinders, M^3-M_3, deeply imbedded, were excavated from the skull and jaw, then placed in natural position for photography. Striking points are: (1) Persistence of the profound median sulcus which separates the inner and outer lobes, as a highly distinctive Mastodontine character (see Pl. I, between pp. 134–135, this Memoir); (2) the excessively sharp, elevated crests strongly compressed fore and aft and approximating the summits; (3) the extreme binary fission of the summits of these crests seen especially in lophs and lophids I and II in which as many as twenty-one conelets may be counted; (4) loph III still retains the two primary cones, highly compressed; (5) the molar is correspondingly broad and short, M^3 measuring approximately 5½ in. in length (140 mm.) and 3¼ in. in breadth (83 mm.).

TURICIUS IN THE STAATS-SAMMLUNG FÜR PALÄONTOLOGIE UND HISTORISCHE GEOLOGIE IN MUNICH[1]

Through the courtesy of Dr. Ernst Stromer, notes, casts, and photographs of *Turicius turicensis* in the Staats-Sammlung für Paläontologie und historische Geologie in Munich were sent to the American Museum for use in the present Memoir.

The following specimens add the welcome knowledge of the complete structure of (a) the superior and inferior tusks; (b) the slender inferior mandible with elongated rostrum; (c) the abbreviated horizontal incisors; (d) the elongated ulna and tibia, relatively much more slender than those of *Trilophodon* or *Mastodon;* (e) the abbreviated manus and pes:

Referred Turicius turicensis from the Upper Miocene of Upper Bavaria

Fig. 657. Inferior jaws with incisors, superior second and third molars, and superior tusks of *Turicius turicensis* ref. from the Upper Miocene of Freising (upper) and Tutzing (lower), Upper Bavaria. From original photographs loaned by Dr. Ernst Stromer. Staats-Sammlung für Paläontologie und historische Geologie, Munich.

[1][Owing to the unfortunate death of Professor Osborn, the description alluded to on page 202 above cannot be given as completely as was originally intended.—Editor.]

TURICIUS TURICENSIS, UPPER MIOCENE[1] OF UPPER BAVARIA

From Freising:

Inferior jaw with I_2, M_2, and M_3 *in situ*, M^2 and M^3, and superior tusks. See figure 657 (upper).

Right M_2 (1899 IX 1b—cast Amer. Mus. 22492). See Plate III, G.

From Tutzing:

Inferior jaw with I_2, M_2, M_3, superior molars, M^2, M^3, and tusks, associated with skeleton of fore- and hindlimb (1912 I 26). See figure 657 (lower).

From Moosburg:

Right M^2 (1891 I 50—cast Amer. Mus. 22491). See Plate III, G.

From Glonn, near Indersdorf:

Fragment of right lower jaw with Dp_4 and M_1 (1916 I 1—cast Amer. Mus. 22493). Not figured.

MEASUREMENTS, IN CENTIMETERS, BY STROMER

Left, upper J [incisor] over 117 cm. long; 30 cm. behind the anterior end, 5.8 cm. across, 8 cm. high; 85 cm. behind the anterior end, 7.6 cm. across, 12 cm. high.
Right, upper M 3 15 cm. long and 9.3 cm. wide.
Right, lower M 3 15.3 cm. long, and 7.8 cm. wide.
Right lower jaw restored to a great extent with plaster, about 90 cm. long; under the M 3, on the inside, about 16 cm. high.
Left ulna, distance between upper and lower joint, 85 cm.
Left ulna, distance between upper and lower articular surface, 72 cm.
Left metacarpal III 18 cm. long.
Right tibia, distance between upper and lower joint, 70 cm.
Right tibia, distance between upper and lower articular surface, 68 cm.
Right tibia shaft, in the middle, 8.5 cm. wide.
Right metatarsal III 13.9 cm. long.

NEW ZYGOLOPHODONTINÆ (TURICIUS, ZYGOLOPHODON) OF CHINA

Dr. A. Tindell Hopwood of the British Museum (Natural History) has kindly sent to The American Museum of Natural History casts of the significant mastodontoid specimens described in his recent Memoir, "Fossil Proboscidea from China" (1935.1). The most welcome addition to our knowledge of the South Asiatic distribution of the Mastodontidæ is Hopwood's recording of a member of the true *Turicius* phylum from the Lower Pliocene of China which he erroneously identifies with our Pleistocene *Mastodon americanus*.

In Chapter VII of the present Memoir is demonstrated the separation of the Zygolophodontinæ, namely, the genera *Zygolophodon* and *Turicius*, from the rest of the family Mastodontidæ. The distinctions between the classic genus *Mastodon* and these two generic phyla are clearly shown in Plates I, II, and III (pp. 134–135, this Memoir). In these plates Osborn has figured diagrammatically the characteristic stages of *Mastodon*, *Zygolophodon*, and *Turicius*, showing that *Mastodon* preserves four subequal conelets on each ridge-crest while *Zygolophodon* rapidly progresses from four to six conelets and *Turicius* adds an even greater number.

Osborn, therefore, cannot accept Hopwood's specific determination of the Pontian remains as *Mastodon americanus* of the North American Pleistocene, but refers to *Turicius* this "left ramus of juvenile mandible with the deciduous dentition" (Hopwood, *op. cit.*, Pl. VI, fig. 5; see also our figure 658).

[1] "Moreover, we determine the Upper Miocene as immediately preceding the Pontian level, whereas the French school puts the Pontian level in the Upper Miocene." (Translated from a letter from Dr. Stromer, Feb. 28, 1935.)

TURICIUS SP.

The horizon and localities given by Hopwood are as follows (*op. cit.*, pp. 43, 44): "*Horizon.*—Lower Pliocene, Pontian, specimens from Shansi (Loc. 49) and Shensi (Loc. 51); Pontian, fragments from Shansi, Hsi Kou *fide* Teilhard; not known, probably Pontian, specimen from Chihli (Loc. 47), *fide* Teilhard."

"*Localities.*— Shansi, Pao Tê Hsien, Chi Chia Kou, Yang Mu Kou, (Loc. 49); Shansi, Wu Hsiang Hsien, NW 18 li, Chu Chia Wa, S ½ li, Hsi Kou; Shensi, Fu Ku Hsien, Wu Lan Kou, Pei Hou Kou, (Loc. 51); Chihli, Hsuan Hu Hsien, from city 40 li, Chao Chia Wan, from village SE, Huang Tui Kou, (Loc. 47)."

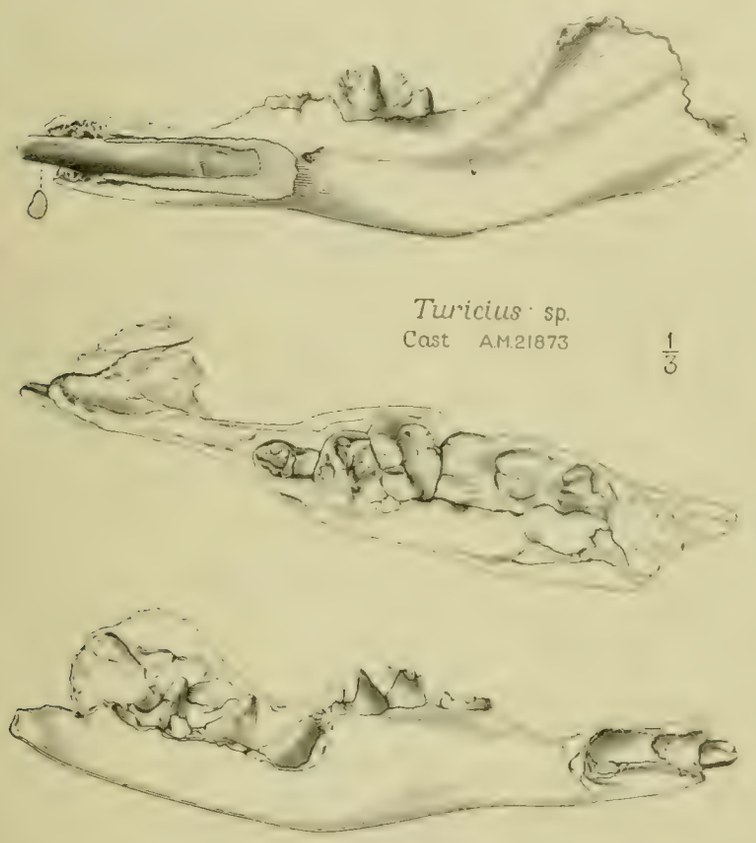


Fig. 658. "Left ramus of juvenile mandible with the deciduous dentition." China. Referred by Hopwood (1935.1, Pl. VI, fig. 5) to "*Mastodon americanus*"; regarded by Osborn as referable to *Turicius*. Original drawing after cast Amer. Mus. 21873. One-third natural size.

In his 'material' Hopwood also mentions "an entire, but partly worn, third lower molar" (*op. cit.*, p. 43), but does not figure the specimen nor have we received a cast. The third lower molar would be corroborative as definitely establishing the reference to *Turicius* rather than to *Mastodon americanus*.

ZYGOLOPHODON BORSONI REF. OF SHANSI, CHINA

Mastodon borsoni Hays ref. On his Plate VII, fig. 1 (Fig. 659 of present Memoir), Hopwood figures a third left lower molar of *Zygolophodon* which he describes as follows (Hopwood, 1935.1, pp. 46, 47):

"*Mastodon Borsoni* Hays. . . *Diagnosis.*— A zygodont mastodont of large size; pretrite cusps of the molar teeth with unusually strong inner cones; ridge-crests very wide; lateral slopes of the pretrite cusps steep.

Material.— A left third lower molar.

Dimensions.— Length 171, Breadth 87 ii, Height 69 iii, Index 50.8.

Horizon.—Unknown.

Locality.—Shansi, Ho Shun Hsien, SW 120 li, Niu T'sao Kou.

Description.—The tooth is from an adult animal; both the first and second ridges have the dentine exposed, and the enamel of the third ridge is abraded. It consists of four ridges and a talonid. Each cusp has the inner cone distinctly marked off from the outer, and although this is most noticeable on the post-trite side it is almost equally clear on the pretrite side. The accessory folds in the enamel of the outer cone of the pretrite cusps are relatively weak: the slope of the labial surface of the same cones is steep. Anteriorly there is a cingulum which is reduced, and there is a strong cingule at the pretrite entrance to the first valley. The talonid is stout and shelf-like: it is composed of four conules with obtuse, flattened tops."

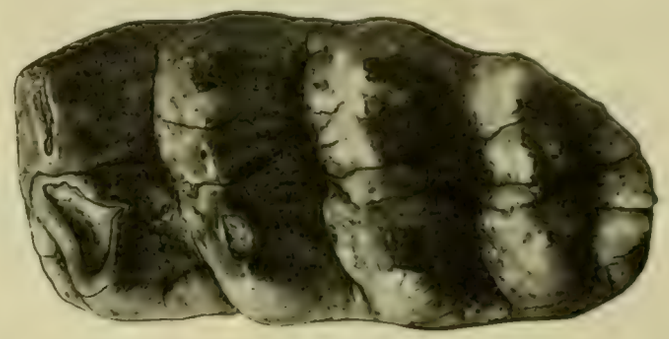


Fig. 659. *Zygolophodon borsoni* ref. Third left inferior molar. After Hopwood (1935.1, Pl. VII, fig. 1). One-half natural size.

Osborn, 1935: As set forth above and in accordance with the definitions in Chapter VII of the present Memoir, Osborn is including this specimen in the species *Zygolophodon borsoni*.

SUPERFAMILY: MASTODONTOIDEA Osborn, 1921
FAMILY: MASTODONTIDÆ Girard, 1852

STEGOLOPHODONTINÆ subfam. nov.

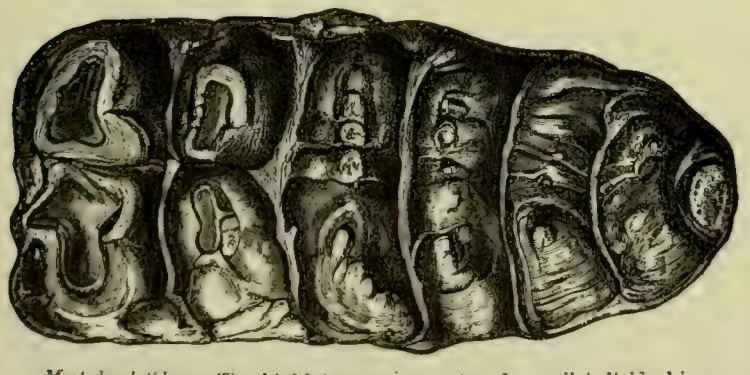
Typical genus: *Stegolophodon* Schlesinger, 1917. This subfamily, transitional in molar tooth structure between the Mastodontoidea and Stegodontoidea,[1] is characterized as follows:

Anterior ridge-crests with persistent median sulcus and four (*Stegolophodon latidens* type) to more numerous (*S. stegodontoides* type) conelets. Posterior ridge-crests (*Stegolophodon lydekkeri* sp. nov., *S. stegodontoides*, *S. cautleyi*) with very numerous conelets paralleling those of true Stegodontoids. Widely distributed geographically in Europe and Asia, persistent into the Middle Pliocene, Perim Island of India (*S. cautleyi*), contemporaneously with the true Stegodontinæ, e.g., *Stegodon bombifrons* of the Dhok Pathan of the Siwaliks, Middle Pliocene.

Stegolophodon is of intense phylogenetic interest because of the intermediate position of its molars between the true Mastodontidæ (*Mastodon*, Pl. I; *Zygolophodon*, Pl. II; *Turicius*, Pl. III) and the true Stegodontoidea. The molar characters of the various species of *Stegolophodon* are most carefully displayed in Plate IV (pp. 134–135) and figure 661 of the present Volume and will be reproduced in Volume II. The persistent *median sulcus* (shaded in Pl. IV) is highly characteristic of the Mastodontidæ. Accordingly *Stegolophodon* points toward a very remote relationship between the Mastodontoidea and the Elephantoidea; in fact, the most primitive elephantoid molar we know, that of *Archidiskodon proplanifrons* of South Africa, is, in section, very like the molar teeth of a *Mastodon*, that is, without any trefoils or central conules blocking the valleys.

In this intensive reëxamination of these various species of *Stegolophodon* we have discovered very wide differences between the types of *Stegolophodon sublatidens* Schlesinger, 1917 (Pl. IV, A), and *S. latidens* Clift, 1828 (Pl. IV, E), and a molar tooth from Borneo which Lydekker (1885.2, 1886.1, 1886.2) described and figured as '*Mastodon latidens*' Clift. This molar Osborn selects as the type of a new Pliocene species dedicated to his friend Richard Lydekker, as follows:

Fig. 19.



Mastodon latidens.—The third left upper true molar of a small individual in a partially-worn condition; from the Pliocene (?) of Borneo. ⅔. The lower border of the figure is the inner border of the specimen. (From the 'Palæontologia Indica.')

Fig. 660. *Stegolophodon lydekkeri* sp. nov. Third left superior molar exhibiting six ridge-crests and a talon. Figured by Lydekker, 1886.2, fig. 19, as *Mastodon latidens*. Compare Lydekker, 1885.2, Pl. XLVIII, and Pl. IV of this Memoir. Two-thirds natural size.

[1]New superfamily (name only), see Osborn, 1935.937, fig. 2.

Stegolophodon lydekkeri sp. nov.

Figure 660, also Pl. IV, G

TYPE.—Third superior molar of the left side, l.M³, original in the Zoological Society of London; cast in the British Museum (M.2498). HORIZON AND LOCALITY.—(Lydekker, 1885.2, p. 777): "The specimen forming the subject of the present notice was forwarded from Borneo to the Secretary of this Society by Mr. A. H. Everett, C.M.Z.S., who stated that it was found during the early part of the present year [1885] by a Kadayan in the jungle in the vicinity of Bruni, on the north-west coast of Borneo." Pliocene (?). TYPE FIGURE.—Lydekker, 1885.2, Pl. XLVIII, figs. 1 and 2; see also Lydekker, 1886.1, fig. 7, 1886.2, fig. 19, as well as Plate IV and figure 660 of this Memoir.

DESCRIPTION.—(Lydekker, 1885.2, pp. 777, 778, 779): "The specimen is the crown of the last left upper true molar of a tetralophodont *Mastodon*, and agrees so closely with Indian teeth of the Siwalik *Mastodon latidens*, Clift [Footnote: 'Trans. Geol. Soc. ser. 2, vol. ii, pt. 3, p. 371 (1828).'], that it may be safely referred to that species, although it indicates a very small in-

dividual. . . . It will be seen that the Borneo specimen agrees [with *M. latidens* of the Punjab[1]] in the number of ridges (although the hind talon is considerably smaller), but is of greatly inferior size, the dimensions of the two specimens being as follows, in inches:—

	Punjab.	Borneo.
Extreme length.....	8.6	6.3
Width of first ridge.....	4.2	2.95"

"It may be added that *Mastodon latidens* is an interesting form, since it is one that apparently passes insensibly into other species. Thus the normal number of ridges in the 'intermediate' molars is four, but a fifth is occasionally present [Footnote: '*Vide* Pal. Ind. ser. 10, vol. i. pl. xxxviii.'], in which case there is but one step to the simplest of the stegodont Elephants, viz. *Elephas clifti*, in which there are six ridges."

Osborn, 1935: The type is an l.M^3 (cf. Pl. IV, G, pp. 134–135) with six ridge-crests (I–VI) and a talon, two anterior ridge-crests (I, II) with four conelets widely separated by a median sulcus; four posterior ridge-crests (III–VI) with 5–5–7–4 conelets, no trace of median sulcus. Thus *Stegolophodon lydekkeri* is much more progressive than the *S. latidens* type (Pl. IV, E) in which the median sulcus appears in ridge-crests I–IV and the conelet formula is: I–4, II–4, III–5, IV–4, V–4, VI–5. Ridge-crest IV more prominent in *S. lydekkeri* than in *S. latidens*. Total conelets in ridge-crests I–VI of *S. lydekkeri* is 29; total conelets in ridge-crests I–VI of *S. latidens* is 26. Observe closure of median sulcus and transverse regularity of conelets in ridge-crests III–VI.

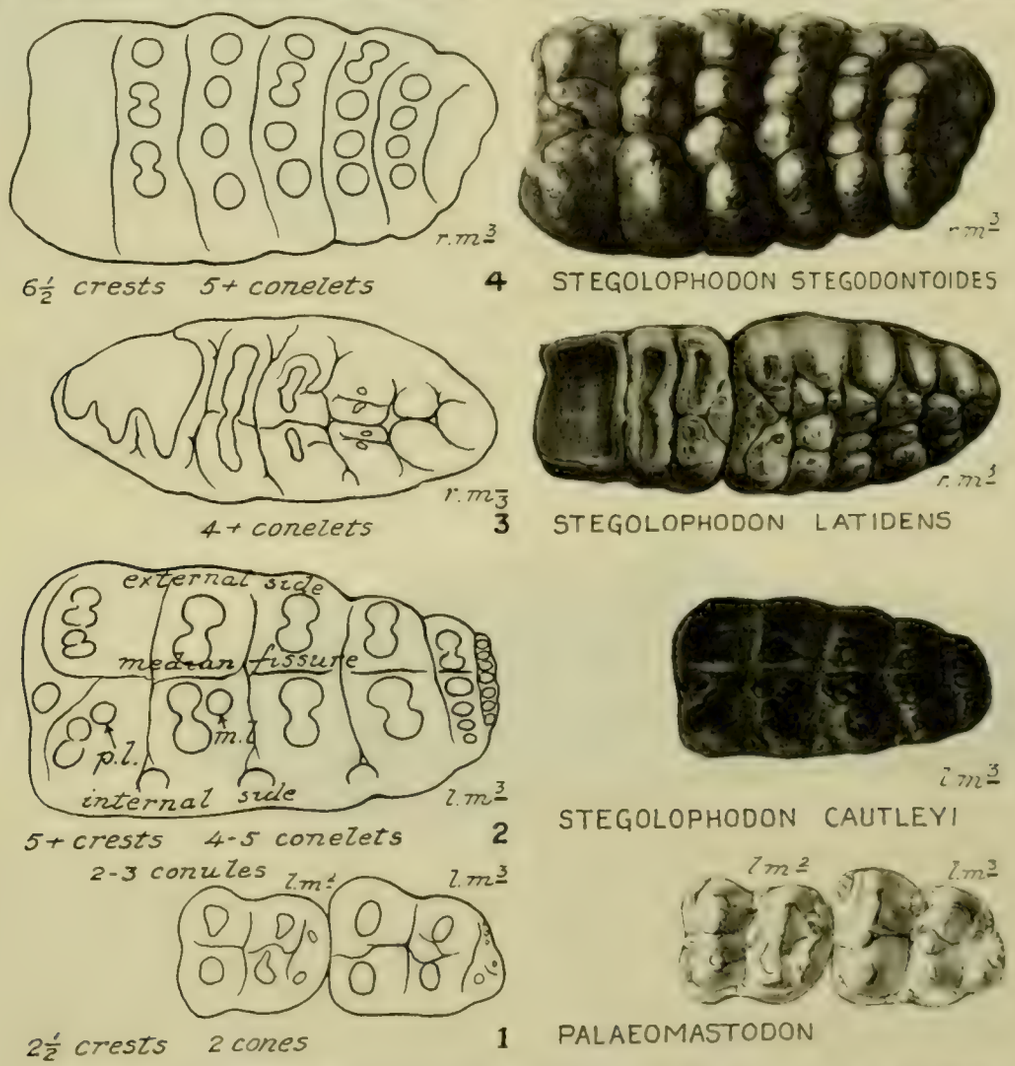


Fig. 661. Structural Evolution of the Cones, Conelets, and Ridge-crests in the Stegolophodon Phylum, in comparison with Palæomastodon.

(1) Palæomastodon, Primary Type. Four primary cones; ridge-crests, proto-, meta-, and rudimentary tritoloph. [See pp. 143 and 691 for subfamily position of *Palæomastodon*. Editor.]

(2–4) Stegolophodon Phylum. Binary fission of *primary cones* into four to five *conelets*, vestigial conules in *S. cautleyi* and *S. latidens* (protoconule = p.l., metaconule = m.l.); addition of trito-, tetarto-, penta-, and hexalophs. Gradual loss of *median sulcus*, persistent, however, in the first two anterior crests.

Stegolophodon latideus (3, left) is a third lower molar, r.M$_3$, inserted for comparison, and has seven plus (7½) ridge-crests, four plus conelets, and median sulcus.

[1]Made the type of *Mastodon* [*Stegolophodon*] *stegodontoides* Pilgrim, 1913.

Family: BUNOMASTODONTIDÆ Osborn, 1921

NEW TRILOPHODONT LONGIROSTRINES OF CHINA

Dr. A. Tindell Hopwood of the British Museum (Natural History) published in February, 1935, his memoir entitled "Fossil Proboscidea from China" including the description of two new trilophodonts, *Trilophodon connexus* and *T. spectabilis*. These species are especially welcome as the first remains of *Trilophodon* discovered in China. A third species referred to *Trilophodon* by Hopwood, *Trilophodon wimani*, proves to belong to *Serridentinus* and is discussed in this Appendix under the family Serridentidæ (pp. 731, 732). Hopwood also added a new species of *Tetralophodon*, *T. exoletus*. These four new species may be described by excerpts from Hopwood's own text.

Trilophodon connexus Hopwood, 1935

Hopwood, 1935, Pl. v, fig. 1 (Fig. 662 of present Memoir)

(Hopwood, 1935.1, pp. 14, 15): "*Horizon.*—Miocene."

"*Locality.*—Kansu, Sining Fu, SW 20 li, Shui Ch'üan P'u, SE 5 li, Tiao Kou."

"*Diagnosis.*—A *Trilophodon* in which the dentition is angusticoronate, bunodont, and moderately hypsodont; pretrite and post-trite cusps of upper molars, normal or subnormal to the long axis of the tooth; valleys wide, but obstructed by the pretrite accessory structures; basal cingulum strong: lower molars with the pretrite cusps oblique, and the post-trite cusps normal, to the long axis; pretrite cusps with anterior or posterior buttresses, or both; valleys completely closed by vallecular conules."

"*Holotype.*—A left mandibular ramus containing the part-worn second molar, and the third molar just entering into wear [Pl. v, fig. 1]."

"[*Referred*] *Material.*—A left fourth upper premolar; an unworn third upper molar [Pl. v, fig. 2]; a left mandibular ramus with the third milk-molar, third premolar, and first molar; a right fourth lower premolar; a very worn left lower first molar; a left second lower molar, unworn but very badly crushed; another specimen of the same tooth, uncrushed but very worn."

"*Dimensions.*—[with some omissions]

	Length	Breadth	Height	Index
Upper M3 [ref.] ii	123	60.5	50.7	49.2
Lower M2 [type] viii	102	49.8	31	48.8
Lower M3 [type] ix	145.5	51.8	45	35.6"

"Of these teeth, iii, iv, v are those in the smaller mandible, whereas viii, ix are those in the holotype ramus. The remainder are isolated specimens."

Relationships.—As to relationships the author observes (*op. cit.*, p. 102): "The most primitive form discovered in China is *Trilophodon connexus* which has affinities with *Tri. cooperi* Osborn from Baluchistan, as well as with the European *Tri. angustidens*. Of the three species the last is the more advanced and farthest away from the ancestral line. *Tri. connexus* is the most primitive and, apart from its greater hypsodonty, would do fairly well as the representative of a stage a little earlier than *Tri. cooperi*."

(*Op. cit.*, p. 18): "Of all the primitive Trilophodonts hitherto described, that which approaches most nearly to *Tri. connexus* is the form [*Trilophodon cooperi* Osborn] from Baluchistan mentioned above, a third upper molar of which (M 12180 Brit. Mus. Geol. Dept.) is nearly indistinguishable from the third upper molar of *Tri. connexus*. The Indian tooth [*T. cooperi*] is wider than the Chinese [*T. connexus*], the breadth indices being 64 and 50.7 respectively. Moreover, the Indian tooth is more advanced since the accessory structures are stronger, and more distinct, and the third ridge is better developed. On the other hand, the Chinese tooth is more hypsodont, for, although the two teeth are of approximately the same height, the Indian tooth is the broader of the two."

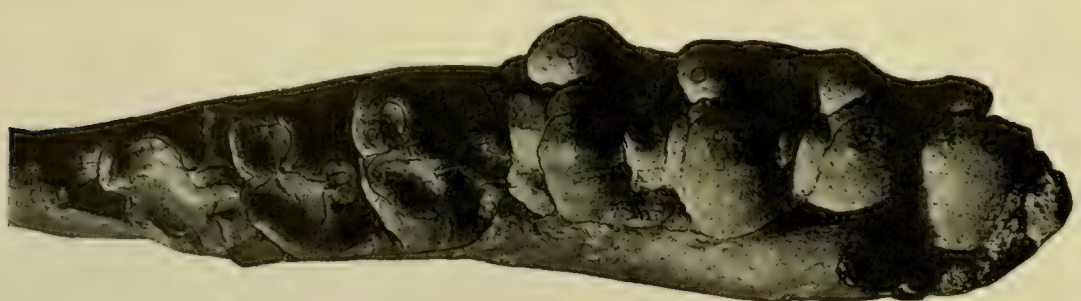


Fig. 662. *Trilophodon connexus* Hopwood, 1935. Type left mandible with second and third molars exhibiting prominent central conules. After Hopwood (1935.1, Pl. v, fig. 1). One-half natural size.

Trilophodon spectabilis Hopwood, 1935

Hopwood, 1935, Pl. vi, fig. 2 (Fig. 663 of present Memoir)

(Hopwood, 1935.1, pp. 30, 31): "*Horizon.*—Unknown."

"*Locality.*—Unknown. The label on the specimen reads, 'Sent febr. 1923 by Rev. Beinhoff. Said to have come from Sian.'"

"*Diagnosis.*—A *Trilophodon* of medium size with hypsodont, angusticoronate dentition; pretrite cusps markedly oblique, post-trite cusps normal, to the long axis; accessory vallecular cusps median, completely obstructing the valleys; cingulum absent, except in front; cement plentiful."

"*Holotype.*—A left lower third molar, partly worn and lacking the talonid."

"*Dimensions.*—Length 176 mm, breadth 65 mm, height of second ridge in excess of 65 mm. These measurements are taken from the holotype without any allowances for breakage or wear."

"*Description.*—The summits of the first six cusps have all been removed by wear; those of the seventh and eighth cusps were broken off before burial. Everything behind the fourth ridge has been lost."

"The pretrite cusps are distinguished by their extreme obliquity to the longitudinal axis, which is so great that the outer cones alternate with those of the post-trite cusps. Each cusp is composed of two cones, though, from the fifth cusp, it appears that the inner, smaller, cone was divided at the summit. The post-trite cusps are normal to the long axis, and composed of two

Fig. 663. *Trilophodon spectabilis* Hopwood, 1935. Type third inferior molar of the left side. Observe prominent central conules. After Hopwood (1935.1, Pl. vi, fig. 2). One-half natural size.

cones. The only exception is the eighth cusp, which is slightly oblique. This condition is very common in the ridge next to the talonid in all species of mastodonts."

"The accessory structures are restricted to the pretrite side almost without exception. The first cusp has a tall cone anteriorly, which forms a buttress merging with the strongly nodular antero-external cingulum. Behind the same cusp is a large vallecular cone, or group of cones, which wears with a trefoil section. The third and fifth cusps have each a posterior vallecular cone, but no anterior cone. There is a small cone closely adpressed to the anterior surface of the inner cone of the sixth cusp. Apart from this, the post-trite cusps have no accessory structures. There is no cingulum other than that just mentioned. All the valleys are filled with cement."

"*Discussion.*—In certain respects, this is the most advanced of the *Trilophodon* group. None other has such hypsodont teeth, and so copious a supply of cement, and in none are the pretrite cusps so oblique to the long axis of the tooth. The species which, although much more primitive, shows the greatest superficial resemblance to this one is that described by Lydekker (1884; pl. iv, figs. 3, 8; pl. v, figs. 1, 1a) as *Mastodon angustidens* var *palæindica*."

Comparative Measurements

	Length	Breadth	Height	Ridge-crests	Index
T. spectabilis Hopwood, holotype, l.M_3	176	65	65 (2nd loph)	4½	36
T. palæindicus Lydekker, type, r.M_3	148	63		4½	43
T. cooperi Osborn, type, r.M_3	147	63		4⅕	43

Osborn, 1935: *Trilophodon spectabilis* is a true *Trilophodon*, with prominent central conules, typified by an l.M_3 lacking talonid or rudimentary pentalophid.

TETRALOPHODONTS OF CHINA AND INDIA

Tetralophodonts are rare in Eurasia, those previously described from India and China including the following:

Tetralophodon (*Lydekkeria*) *falconeri* Lydekker, 1877, Dhok Pathan, Potwár district, Punjab, India; Mio-Pliocene. As compared with *Pentalophodon sivalensis* with which Falconer connected this species Osborn remarks: "The ridge formula is M 2^{1}–M 3^{1½}. These grinding teeth, therefore, correspond with the rather primitive species *Tetralophodon* (*Lydekkeria*) *falconeri*, much more primitive than *Tetralophodon punjabiensis* and not far distant in their evolutionary stage from *Tetralophodon* (*Lydekkeria*) *sinensis*." (See Figs. 309–311, pp. 353–355 of this Memoir.)

Tetralophodon (*Lydekkeria*) *sinensis* Koken, 1885, Yun-nan, China; Mio-Pliocene. (See this Memoir, pp. 353–355, Fig. 311.) Type third left superior molar with five ridge-crests, trefoils on the internal side of the crown only, thus clearly distinguished from *Tetralophodon longirostris;* more primitive than *Tetralophodon falconeri*. Osborn thus differs from Hopwood, who remarks (1935.1, p. 41): "Without examining the original specimen, or a good cast, it is not feasible to make any definite statement concerning the relationships of this species, but it seems certain that it is an advanced member of the *T. longirostris* group, and that its age is Pliocene."

Tetralophodon exoletus Hopwood, 1935

Figure 664

Tetralophodon exoletus Hopwood, 1935. (Hopwood, 1935.1, p. 36): "*Horizon.*—Pontian. *Locality.*—Shansi, Pao Tê Hsien, Chi Chia Kou, Sang Chia Liang Kai, Loc. 43; holotype and paratype. Loc. 110 (2) in the Province of Shansi; deciduous dentition. Shansi, Pao Tê Chou, NE 20 li, P'u Fang Yen, N 1½ li, Ch'i Tsu Kou; isolated Dm4."

(Hopwood, *op. cit.*, pp. 101, 102): "*Tetralophodon exoletus* occurs with *Ictitherium, Hyæna, Indarctos?, Dicerorhinus, Chilotherium, Hipparion, Chleuastochærus, Palæotragus.*" . . .

"From these lists it is clear that there is little speculation in assuming the Pontian age of the fossils identified as *Tetralophodon exoletus*, and *Mastodon americanus*. The general agreement between the accompanying faunas and that of Pikermi is so close that it is impossible for the beds to be regarded as other than homotaxial."

(*Op. cit.*, pp. 35, 36, 38, 40): "*Diagnosis.*—A *Tetralophodon* of large size with hypsodont, angusticoronate dentition. Third lower molars with 6½ ridges and talonid, intermediate lower molars with 4 to 4½ ridges. Milk dentition with wrinkled enamel, and pronounced cingulum; permanent teeth with smooth enamel and no cingulum."

"*Holotype.*—A partly erupted and worn right lower third molar with part of the mandibular ramus still attached [Pl. vi, fig. 3; see also Fig. 664 of the present Memoir]."

"*Paratype.*—A broken right mandibular ramus with the worn fourth deciduous molar, the partly erupted third premolar, the fourth premolar still in its crypt, and the first molar about to erupt. [Pl. vi, fig. 4.]"

"[*Referred*] *Material.*—A third upper left deciduous molar, incomplete behind; one lower second deciduous molar; two lower third deciduous molars; one partly worn left lower fourth deciduous molar; one left lower third premolar."

"*Dimensions.*—[with some omissions]

Lower Dentition	Length	Breadth	Height	Index
Holotype M3	272 (295?)	102	73.5	34.5 ?
Paratype M1	120 ?	55 ?	45 ?	45.8 ?
Paratype Dm4	87	52	....	57.7
Paratype P3	38	30	22.5	79"

Type Description.—"The holotype is broken both in front and behind; the first molar of the paratype is in such a position that the dimensions can only be estimated; the fourth premolar of the paratype is badly distorted through deposition of crystalline calcite in and about the partly calcified germ."

"The third lower molar [r.M_3], which is incomplete, consists of six ridges and a talonid [7th ridge-crest]. Each cusp is composed of two cones which are nearly equal in size. The most anterior complete post-trite cusp, the fourth, shows signs of wearing with a trefoil section; this is not due to accessory structures, but to an antero-posterior extension of the inner cone. Similar extension of the inner cone is seen in all the post-trite cusps. The pretrite cusps also wear with a trefoil pattern, but this is achieved differently. The external lobe is formed by the outer cone of the cusp; the anterior lobe by the inner cone, which is somewhat in advance of the outer, and, hence, the cusp is oblique whereas the posterior lobe is formed by a large posterior accessory cone. The talonid consists of three cones, two pretrite, and one post-trite; its extreme posterior portion is lost, but there seems to have been a cone on the median line of the tooth."

Fig. 664. *Tetralophodon exoletus* Hopwood, 1935. Type right third inferior molar. After Hopwood (1935.1, Pl. vi, fig. 3). Observe seven ridge-crests, I–VII. Crests I–VI divide into four conelets, more or less prominent trefoil spurs on ectoconelets I–VI. One-half natural size.

"The only accessory structures are the posterior cones already mentioned, and they are formed from a posterior fold on the outer cones of the pretrite side by division. There are vestiges of cingules on the pretrite side, but none on the other. The anterior cingulum, if present, has been lost. There was little or no cement."

"The American species which bear most resemblance to *T. exoletus* are *T. campester* (Cope), *T. elegans* (Hay), and *T.* (*Morrillia*) *barbouri* Osborn. From all these it is to be separated by its larger size, by its ridge formula, and by the small breadth index of

the third molar. These differences are common to all three species; others such as presence or absence of cement, development of the trefoils, and height of the ridges, are individual."

"Thus, *T. exoletus* has its closest affinities with the species found in the Pontian of Europe, but little or none with those in the Pliocene of America. It is more advanced than any of the forms with which it has been compared."

Osborn, 1935: Osborn characterizes this tooth (r.M_3) as possessing seven ridge-crests and the rudiments of a talonid, a small median conelet; six anterior crests composed of four conelets; seventh crest composed of three conelets; prominent anterior and posterior trefoils on the three anterior ridge-crests, posterior trefoil on ridge-crest four; rudiments only of post-trefoils on ridge-crests 5 and 6. This appears to be a primitive *Tetralophodon* molar, seven ridge-crested. It may be compared with other Eurasiatic and American species as follows:

It is much more primitive than Kaup's *Tetralophodon longirostris* (Fig. 315, p. 358, this Memoir) since *T. longirostris* exhibits double trefoils, both internal and external, upon its five and a half crested M^3.

It is more primitive than the six ridge-crested *Tetralophodon grandincisivus* (Fig. 318, p. 361, this Memoir); it is much more primitive than the six ridge-crested *Tetralophodon punjabiensis* Lydekker (Fig. 322, p. 363; Fig. 325, p. 365, this Memoir). While backward in the development of its trefoils, it is progressive in the possession of seven ridge-crests, a very unusual character.

Tetralophodon exoletus Hopwood is thus an exceptional seven ridge-crested stage of *Tetralophodon*, primitive in the development of its trefoils and progressive in the addition of a seventh ridge-crest.

AMERICAN BUNOMASTODONTS

While closely resembling each other in the third superior and inferior grinding teeth, the Longirostrinæ of the ancient western plains of America are differentiated in the form of the rostrum and of the mandible, in the shape of the inferior tusks, and in the presence or absence of inferior tusks. Chiefly by Barbour and secondarily by Frick and Osborn, this differentiation has been indicated by subgeneric terms. Doubtless it corresponds with differences of habit, of habitat, and of the plant life in the dry soils and sands or in the shallow waters of the ancient plains region. In Chapter VIII a preliminary grouping of the subgenera and the ascending order of species has been described on pages 225 to 229. The mandibular and tusk differentiation is somewhat as follows:

Typical *Trilophodon*, prod-tuskers, lower incisors nearest to *Trilophodon angustidens*.

Trilophodon (*Tatabelodon* Frick), signifying ancient-tuskers, inferior incisors rodlike or triangular.

Trilophodon, signifying oblique-tuskers, tusks flattened, mandible deep, decurved.

Megabelodon Barbour (including *Trilophodon phippsi* see footnote on page 329 above), mandible tuskless, rostrum rounded, terminating in spatulate expansion.

Gnathabelodon Barbour and Sternberg, mandible tuskless with rostrum broadly expanded in front, upper borders deeply grooved, molars widely distinct in pattern from those of *Trilophodon* or *Amebelodon*.

Amebelodon Barbour, typical shovel-tuskers, descendants of *Phiomia* of the Fayûm.

The above differentiation is a sure proof of diversified soil and surface conditions and specialization in the choice of plant foods. The following table of measurements indicates that in general there is progressive increase in size in each of these subgeneric or generic phyla.

ADAPTIVE RADIATION AND PROGRESSION OF THE AMERICAN TRILOPHODONTS, AMEBELODONTS, AND GNATHABELODONTS IN ASCENDING GEOLOGIC ORDER

COMPARE FINAL SUMMARY AND CLASSIFICATION OF GENERA AND SPECIES AT THE CLOSE OF THE APPENDIX

	Third inferior molar	Ridge-crests	Trefoils	Mandible Length of	Tusks Total length	Tusks Length beyond alveolus
TYPICAL TRILOPHODON (SCAPTOBELODONT), 'PROD-TUSKERS,' NEAREST TO TRILOPHODON ANGUSTIDENS						
Trilophodon pojoaquensis	197(M^3)	4⅓	Double	1000e	Distal end of tusk and symphysis missing	
Trilophodon osborni	196	4½	Rudiments of double	1346	500e	249
Trilophodon abeli	185	4½	Rudiments of double	1156	508	216
Trilophodon willistoni (juvenile)			Single	762	225e	102
Trilophodon fricki (very primitive)	172	3¾–4	Single	1134		157
TRILOPHODON (TATABELODON), 'ANCIENT-TUSKERS,' RODLIKE OR TRIANGULAR						
Tril. (Tatabelodon) riograndensis	203	4½	Single (?)	1000e	Distal end of tusks and symphysis missing	
Tril. (Tatabelodon) gregorii	205	4½	Single		558	200e
TRILOPHODON, 'OBLIQUE-TUSKERS,' TUSKS FLATTENED, MANDIBLE DEEP, DECURVED						
Trilophodon dinotherioides	240	4½–5	Rudiments of double	1265e		
Trilophodon ligoniferus	245	4½–5	Rudiments of double		Distal end of tusk and symphysis missing	
Trilophodon giganteus	172	4½–5	Rudiment of double	1560 Ramus massive	850e	160e(?)
MEGABELODON LULLI, TUSKLESS, MANDIBLE SLENDER, ROUNDED						
Megabelodon lulli	222	3½–4		1322[1]	Tuskless	
Megabelodon joraki	180e			1130e	Tuskless	
Megabelodon cruziensis	180	5⅓	Single	1000	Tuskless	
Trilophodon phippsi[2]	232	4+	Single	1486	Tuskless	
GNATHABELODON, SUPERIOR TUSKS MASTODONTOID, ROUNDED, UPCURVED, WITHOUT ENAMEL						
Gnathabelodon thorpei	166	4⅓ sup. 4½ inf.	Double	1524	Tuskless	
PHIOMIA—AMEBELODON, TYPICAL 'SHOVEL-TUSKERS'						
Amebelodon fricki	229	5½	Double on crests 1–4	1475	1144	455
Amebelodon sinclairi					712e	
Amebelodon hicksi	199	5½	Double	1050	380+	
Amebelodon paladentatus	174	4		910	485+	
Phiomia osborni	71		None	680	250	
Phiomia wintoni type	74		None	670	240e	
Phiomia wintoni ref.	70		None		260e	
Phiomia wintoni (adult)	65			640	180	
Phiomia wintoni (juvenile)				520	140	

[1]In Chapter VIII of the present Memoir this measurement was erroneously estimated at 1504 mm.

[2][This species is included with *Megabelodon* because of its tuskless mandible. It was evidently the intention of Professor Osborn to place *Trilophodon phippsi* in the genus *Megabelodon*. See footnote on page 329 above.—Editor.]

THE "SPOONBILL" MASTODONTS[1]

The recent discoveries of Barbour and his field parties of 1935 have revolutionized our knowledge of the extremity of the mandible of *Megabelodon lulli*, the specific type of the genus, so named because of its very large superior tusks (Fig. 243, p. 295, this Memoir), at first (Chapter VIII) erroneously treated by Osborn as a synonym of *Trilophodon*. *Megabelodon* proves to be not only widely distinct from *Trilophodon* but a member of an independent generic line characterized by: (1) *Entire absence of the inferior tusks;* (2) broadening of the mandibular extremity into an obtuse, toothless digging expansion which varies in different species – this toothless structure was shown by Barbour (Barbour, 1934.2, p. 307, fig. 180) in his figures of the two rostra reproduced with the accompanying text (Fig. 666A, B); (3) possible relationship to *Gnathabelodon*.

Barbour first interpreted this rostrum as "presumably for the attachment of a coarse heavy gristly pad usable perhaps in tearing leaves and twigs from the branches." Barbour accordingly (after correcting his error in providing the extremity of the mandible with elongate tusks) restored and renamed this animal (Barbour, 1934.2, p. 305, fig. 179) "*Megabelodon lulli*, the Spoonbill Mastodon," as reproduced in our figure 667. To further establish the "spoonbill" character of *Megabelodon* was the discovery of a perfectly preserved tuskless rostrum (Neb. Mus. 2–25–6–35 N. P.–Fig. 666C) with associated right mandible containing the third molar (Neb. Mus. 1–25–6–35 N. P.—Fig. 245, p. 297), a vertebra, also an upper tusk "within 50 or 75 feet, or possibly at the same spot" where the type of *Megabelodon lulli* was found, namely, "on the east side of the Snake River, about 1/10 mile north of the south line of sec. 28, T. 32 N., R. 30 W., Cherry county, Nebraska," by Frank Walker Johnson, head of the Nebraska State Museum field party at Burge, Nebraska, in the summer of 1935.

The first figure of the rostrum of one of these spoonbilled mastodonts was that of Frick (1933.1, fig. 18) in describing his ?*Amebelodon joraki*, reproduced in this Memoir as *Trilophodon* (*Amebelodon*) *joraki* type (p. 327, fig. 281 A). Osborn erroneously referred this specimen (p. 326) to *Trilophodon joraki;* Frick erroneously entered it as ?*Amebelodon joraki* Frick, 1933. Apparently of the same tuskless "spoonbill" character is Frick's *Trilophodon cruziensis* (Frick, 1933.1, figs. 10, 12A, 17, 23A, 25), redescribed by Osborn as *Trilophodon cruziensis* type (Fig. 281 B, p. 327, this Memoir).

The divergence between these various kinds of spoonbills is shown, first, in the more or less perfect adaptation of the rostrum of the tuskless mandible to its uprooting habits which seems to be most perfect in *Gnathabelodon thorpei;* second, in the correlated relatively simple structure of the third inferior grinding teeth. In *Megabelodon lulli* the third inferior molars are very simple and only four crested; in *Megabelodon joraki* the number of ridge-crests is uncertain; in *Megabelodon cruziensis* the third inferior molars exhibit 5½ ridge-crests and trefoils; in *Gnathabelodon thorpei* there are only 4½ ridge-crests above and 4½ below; the molars are very broad in the last-named species.

Mounted Skeleton of Megabelodon lulli

Director Barbour of the Nebraska State Museum secured in 1931 from the east edge of the Forest Reservation, Cherry County, Nebraska, the partial skeleton referred to *Megabelodon lulli* which was restored and mounted May 31, 1933, and its mandibular structure (Fig. 665) throws important light on the type mandible of *Megabelodon lulli* (Neb. Mus. 10–8–14). Barbour writes as follows (Barbour, 1934.2, p. 303):

[1](Osborn, October, 1935) This section is written at the very moment of going to the final printing, without time for thorough examination and comparison.

"The following parts were secured: the two upper tusks, the mandible, axis, ribs, certain limb bones, a perfect pelvis including the sacrum, and the elements of the left fore limb in articulation from the scapula to the tips of the toes with even the sesamoids in place. The elements of this limb, as seen in the full-page halftone [our figure 667], are held together mainly by the matrix out of which they were chiseled, and the position of the limb inspires the fancy that the creature, in life, startled by some carnivore, had jerked up his foot. This presumptive circumstance furnished the idea for the first pose, which may be used as the final one, after suitable adjustments have been made. In carrying out the conception, this mastodon is mounted in a partly rearing position, and beside it, near a rock, is the skeleton of a crouching sabre-toothed tiger. The design was conceived in response to a strong desire on the part of the field men that these venerable bones found in such perfect alignment should not be irreverently disarticulated. It was a unanimous wish that this limb be mounted as found in the rocks."

"Unfortunately, the skull had weathered away, but the two tusks were left, while the mandible is practically perfect throughout, and is of peculiar interest. The rami of the jaw are massive, and strong, while the rostrum is long, slim, weak, tuskless, and recurved, giving a decidedly rhynchotheroid effect. It is the very tip of the rostrum which challenges first attention. The rostrum is exceptionally thin and narrow, but at the very tip flares into the form of a spoonbill, so this specimen has come to be known familiarly as the Spoonbill Mastodon."

Fig. 665. Mandible of *Megabelodon lulli* ref. belonging to the Cherry County, Nebraska, skeleton (Neb. Mus. 29-7-31). (Upper) Lateral view with two sections. (Lower) Mandible viewed from below, showing long, slender rostrum expanded at the tip, and two rounded prominences. After Barbour, 1934.2, figs. 177 and 178. Both views about one-twelfth natural size.

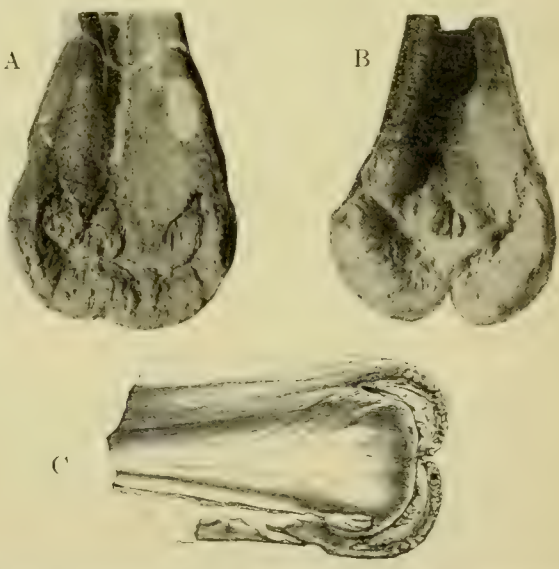


Fig. 666.—"*Megabelodon lulli*, expanded tips of two rostra, each showing a deep symmetrical scar presumably for the attachment of a coarse heavy gristly pad usable perhaps in tearing leaves and twigs from the branches. Viewed from above." Barbour, 1934.2, p. 307, fig. 180.

A, "Expanded rostrum of the specimen in the museum of the South Dakota School of Mines, for comparison. By permission of Dr. O'Hara."

B, "Expanded rostrum of the Spoonbill Mastodon, number 29-7-31, Cherry County, Nebraska. About ⅙ natural size."

Drawn from original specimen kindly loaned by Dr. E. H. Barbour, and inserted for comparison.

C, Tip of rostrum (Neb. Mus. 2-25-6-35) discovered in the summer of 1935 at, or near, the type locality of *Megabelodon lulli* by the University of Nebraska field parties. Associated with right mandible containing third molar (see Fig. 245, p. 297 above). One-sixth natural size.

Mandibles and Rostra of Megabelodon lulli

Doctor Barbour continues his description of this referred specimen (Barbour, 1934.2, pp. 304, 306, 307): "When viewed from below, the flared rostrum [Neb. Mus. 29-7-31] exhibits two hemispherical prominences, as may be seen in the accompanying figure [our figure 665]. Viewed from above, there is seen a deep, symmetrical, roughened scar at the immediate tip, designed apparently for the attachment of heavy muscles. This leads to the conception that the specimen under consideration may have had a powerful opposable lower lip-like appendage. Or, what is more probable, the roughness may have served for the attachment of a coarse opposable gristly pad. Either one might have aided the creature in stripping leaves and twigs from underbrush and boughs. If the scar is merely alveolar, resulting from the abortion of the tusks, the flaring of the rostrum is not without significance."

"The mandible does not seem to be that of a tuskless female, nor a tuskless male, for that matter. It is difficult however to judge, for variability is a law with which to reckon and it operates within wide limits."

"Had a solitary specimen been found instead of several, the tuskless state of this jaw might possibly have passed as a case of aberration. However, with four jaws at hand, all alike even to minor details, the evidence is strongly against any assumption of abnormality."

Fig. 667. Referred skeleton of *Megabelodon lulli*, the Spoonbill Mastodon, represented as having been startled by a sabre-tooth tiger. (Unfinished mount.) Morrill Palaeontological Collection of the Nebraska State Museum 29-7-31. About one forty-fifth natural size. After Barbour, 1934.2, fig. 179.

As quoted above, Barbour mentions "four jaws" of the "Spoonbill Mastodon" and refers to them as follows: "There is one fine example of this type of mastodon, a complete skeleton, *Trilophodon phippsi*, in the Colorado Museum of Natural History, Denver. One skeleton, more or less complete, is preserved in the museum of the South Dakota School of Mines, at Rapid City, and two examples [*i.e.*, the type of *Megabelodon lulli*, Neb. Mus. 10–8–14, and the referred skeleton of *M. lulli*, Neb. Mus. 29-7-31] are to be found in the Nebraska State Museum."

NEW SHOVEL-JAWED GNATHABELODON FROM KANSAS

The discovery of the absolutely unique *Gnathabelodon* is one of the greatest surprises in the long history of the adaptive radiation of the mastodontoid Proboscidea. No one could have dreamed of the evolution of the elongate, broadly spatulate tuskless mandible from a mandible of the ancestral *Mœritherium* type. We were prepared for the degeneration of the lower incisors by the discovery of the tuskless mandible of *Megabelodon lulli*, also by the tuskless mandible of *Trilophodon phippsi*, but the broad, birdlike, toothless bill, which is analogous to that of the duck-billed *Platypus* in the Monotreme order, exhibits an astounding divergence from the usual proboscidean rostrum, as well as from other members of the family BUNOMASTODONTIDÆ to which this surprising new genus belongs. This is another proof of the existence throughout the plains of northern Eurasia and of North America, north and south of the 40th parallel, of great shallow sheets of water which abounded in succulent tubers implanted either in sand or mud of different degrees of density to which the broadened and lengthened incisors of the various kinds of shovel-tuskers were adapted in one extreme, with the tuskless mandibles in the opposite extreme. In *Gnathabelodon*, as described by Barbour and Sternberg, we have a mandible adapted to extremely soft, yielding sedimentary deposits. It is possible, although not probable, that this mandible was partly sheathed in horn. It certainly was sheathed in resistant epidermis.

SUPERFAMILY: MASTODONTOIDEA Osborn, 1921

FAMILY: BUNOMASTODONTIDÆ Osborn, 1921

SUBFAMILY: **GNATHABELODONTINÆ** Barbour and Sternberg, 1935 (emend. Osborn)

Original reference: Barbour and Sternberg, 1935. "Gnathabelodon thorpei gen. et sp. nov. A new mud-grubbing Mastodon." Neb. State Mus., Bull. 42, I, May, pp. 395–404.

SUBFAMILY CHARACTERS.—(Barbour and Sternberg, 1935, p. 396): "This unique, longirostral, mud-grubbing mastodont cannot be referred to the tetrabelodonts, the amebelodonts, or the platybelodonts. Accordingly, we are proposing for this particular 'belodon' the name *Gnathabelodon thorpei*. The generic title is in allusion to its tuskless mandible, and the specific in recognition of the work done on fossil mammals by Dr. Malcolm R. Thorpe."

"*Gnathabelodon* is fully entitled to be placed in a new subfamily, namely, *Gnathalodontinae* [Gnathabelodontinæ]."

OSBORN DEFINITION, 1935.—(1) Lower jaws elongated (longirostral), expanding broadly towards the extremities with an elongated and longitudinally grooved symphysis. (2) Inferior incisive tusks wanting, replaced by a broadly expanded, sharpened bony border, probably sheathed with hardened epidermis. (3) Superior incisive tusks without enamel, rounded, outcurved, probably for defensive purposes. (4) Intermediate grinders trilophodont, in old age reduced to a single pair above and below. (5) Superior and inferior grinding teeth tetra- to pentalophoid, ptychodont, with double entotrefoils and rudimentary ectotrefoils in superior molars, double ectotrefoils on inferior molars. In general, of progressive, bunomastodont type with central conules. Third and fourth crests less progressive with four conelets; fifth crest with two conelets.

Genus: **GNATHABELODON** Barbour and Sternberg, 1935

Generic Characters.—(Barbour and Sternberg, 1935, pp. 396–404) Mandible greatly elongated, i. e., 'longirostral.' Rostrum expanding towards extremity into a broad tuskless anterior border (Barbour and Sternberg, 1935, fig. 188); mandibular symphysis greatly elongated, deeply grooved (*op. cit.*, fig. 187); lateral and terminal borders sharpened, inferior border decurved, terminal border drawn out into a thin edge. Mental foramen very large as in *Megabelodon lulli*. No vestiges of inferior tusks; superior tusks rounded, curved, projecting beyond extremity of mandible; entirely without enamel band, adapted to defensive or uprooting purposes. Superior molars with very prominent internal trefoils on proto- and metalophs, multiplied cones and conelets on trito- and tetartolophs (*op. cit.*, fig. 189); relatively broad, length 205 mm., width 111 mm., index 54. Third lower molars with prominent external trefoils on proto- and metalophs, tritoloph consisting of four irregular conelets, tetartoloph of two cones; rudimentary proto- and metalophids with double trefoils. Tritolophid with four conelets, tetartolophid with two cones, rudimentary pentalophid with two cones; central conules apparently present. Lower molars relatively narrow, length 166 mm., width 99 mm., index 60. Second lower molar apparently trilophoid, relatively small, ap. 99 mm., tr. 63 mm., index 63. Molars a unique combination of characters observed in the Bunomastodontidæ and in the Mastodontidæ.

Osborn, 1935.—The above mandibular and dental characters widely separate *Gnathabelodon* from the shovel-tuskers, flat-tuskers, or any of the remaining genera of the Bunomastodontidæ and Serridentidæ and are in full accord with Barbour's conception of this as representing a distinct subfamily remotely related to the Amebelodontinæ.

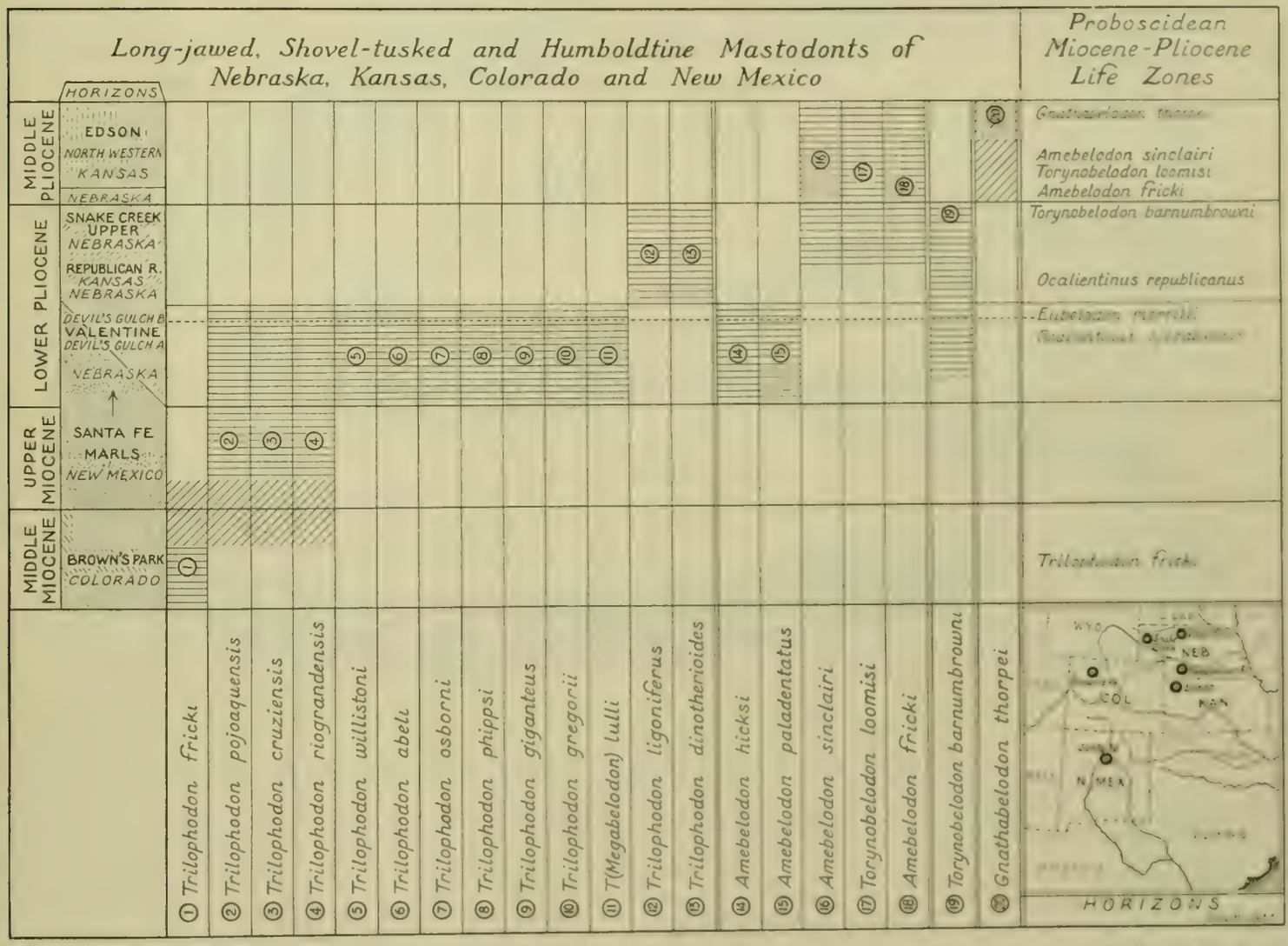


Fig. 668. Chart showing type localities of various members of the Mastodontoidea, including *Gnathabelodon thorpei* of northwestern Kansas (see Pl. VII).

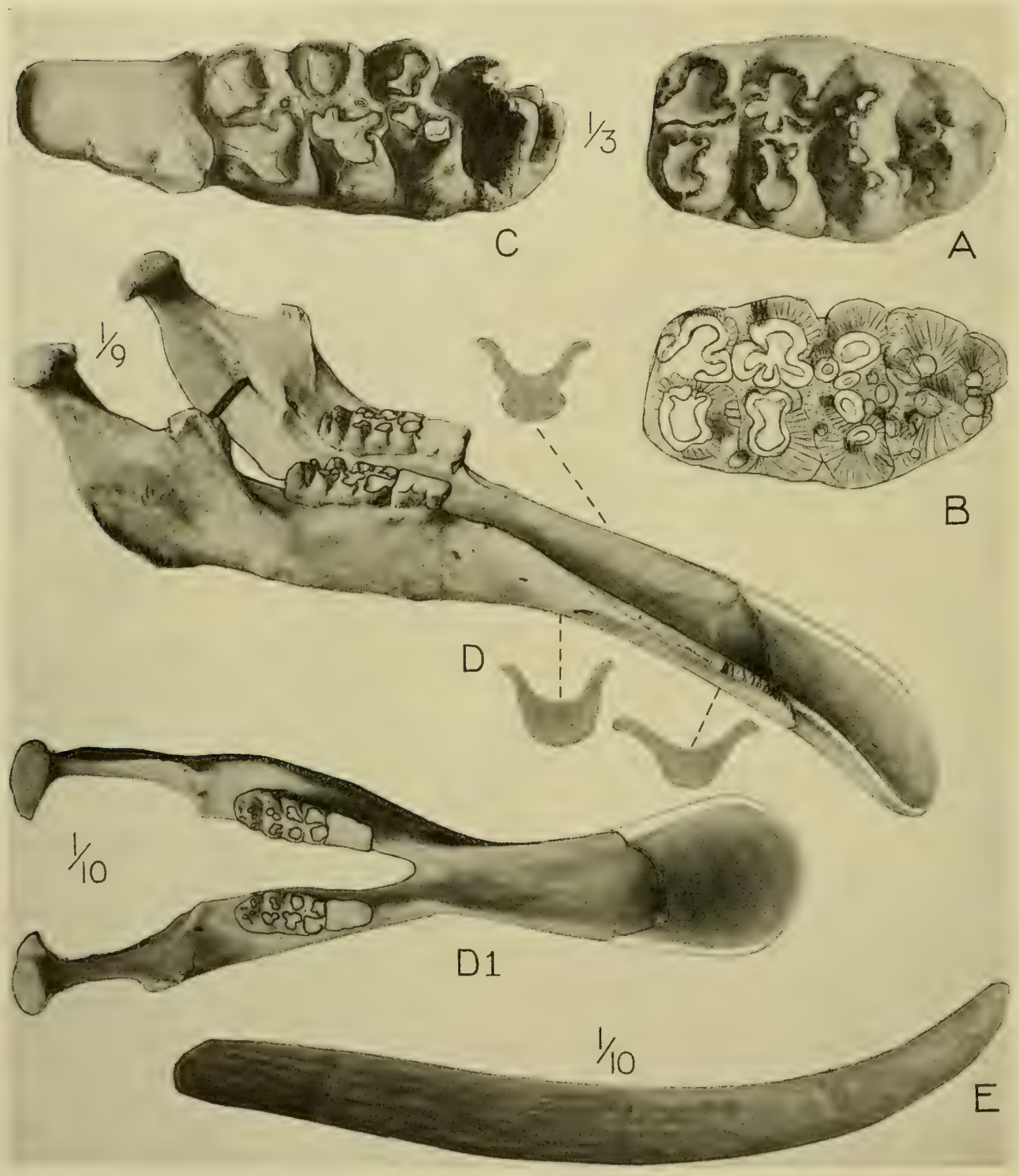


Fig. 669. Type Figure of Gnathabelodon thorpei Barbour and Sternberg, 1935

After original photographs loaned by Doctor Barbour

A, R.M^3 exhibiting four crests and rudimentary talon or pentaloph; length 205 mm., width 111 mm., index 54. One-third natural size.

B, Diagram of the same r.M^3 exhibiting the cones, conelets, and central conules of the proto- and metalophs, also the four conelets of the trito-, tetarto-, and pentalophs, and the double trefoils of the proto- and metalophs. After original drawing by E. H. Barbour. One-third natural size.

C, Small, much worn l.M_2, also the narrow elongate l.M_3 (length 166 mm., breadth 99 mm., index 60). Observe the simple internal cones of the four chief crests, partly subdivided into two conelets; also the proto- and metalophs with double ectotrefoils, also the trito- and tetartolophids with four conelets lacking trefoils. One-third natural size.

D, Oblique side view of the mandible with three sections of the longitudinal mandibular trough, expanding terminal portion as restored, with sharpened edge. One-ninth natural size.

D1, Superior view of same, exhibiting the flaring, tuskless, gouge-shaped terminal rostrum drawn to an edge, as restored. One-tenthnatural size.

E, The robust left superior tusk, length 6 ft. 7 in. (2007 mm.), greatest diameter 6¼ in. (160 mm.). One-tenth natural size.

Gnathabelodon thorpei Barbour and Sternberg, 1935

Figure 669

Gnathabelodon thorpei Barbour and Sternberg, 1935. "Gnathabelodon thorpei gen. et sp. nov. A new mud-grubbing Mastodon." Neb. State Mus., Bull. 42, I, pp. 395–404, text figs. 187–191. TYPE.—Third right superior molar and left tusk, inferior mandible (rostrum partly restored) with second and third molars *in situ*. Fort Hays Kansas State College. HORIZON AND LOCALITY.—A quarter of a mile north, and a mile and a half due east of Ogallah, Trego County, western Kansas, found by Robert Arnold on his ranch, Sec. 24, T.12 S., R.22 W., about twenty miles west and three miles north of Hays, Kansas. "The specimen was found in coarse cross-bedded channel gravel about 12 to 14 feet below the surface, an indefinite amount of material having been weathered off from above. A section at this spot shows four feet of dark clayey soil, and 22 feet of coarse cross-bedded channel gravel, with the skull and mandible near the middle. Professor Maxim K. Elias, of the University of Kansas, who has made special studies of Trego County, when consulted, pronounced this bed Late Pliocene in all probability, although he had not seen a section at this particular gravel pit, and based his opinion on neighboring exposures [*op. cit.*, pp. 395, 396]." Probably Middle Pliocene (Colbert). TYPE FIGURES.—Barbour and Sternberg, 1935, figs. 187–191; also figure 669 of this Memoir.

TYPE DESCRIPTION.—(*Op. cit.*, 1935, pp. 396–404): "The diagnostic characters of *Gnathabelodon thorpei* are about as follows:

The skull was amongst the largest known to mastodonts. Its tusks are long, thick, slightly helical, and are wholly destitute of the customary enamel band....The large tusks of *Gnathabelodon*... curve gently upward and slightly outward, unlike all other longirostral proboscideans known to this region. The mandible is notably long, strong, and massive, and is tuskless. It flares immoderately at the tip, where it comes to a thin sharp edge. The shape of the rostrum is that of a wood carver's gouge, or perhaps that of a shoehorn. Since the tip of the great flaring rostrum is drawn out into a thin edge, lower tusks were obviously precluded. Furthermore, sections of the rostrum show that the alveoli are ossified throughout, leaving no traces of tusks. It is inferred that in this genus inferior tusks had been wanting for an extended period, otherwise all vestiges of them could not have been so completely effaced. The upper borders of the rostrum, instead of coming to the usual edge, are strangely flattened to a full inch in width and are rolled outward as may be seen in the figures and sections. This seems to be distinctive, at least no like modification has fallen under our observation. These flattened borders suggest the possibility that they may have been covered by a calloused hide on which the proboscis pressed, and habitually rested...The total length of this mandible, as it stands, measured

MEASUREMENTS

	inches	mm.
"Mandible		
Width across condyles	20.5	520
Across coronoids	17.5	447
Tip of rostrum, greatest flare	9.25	235
Tip of rostrum restored	10 to 12	255 to 305
Back of condyle to the last molar	18	[460]
Back of condyle to the mental foramen	40.4	1017
Second molar to symphysis	4.5	114
Second molar to mental foramen	12.25	311
Width of mandible, posterior border, molar 3	17	432
Length of jaw from the back of the condyle to the broken tip on the median line	50	1271
Length of jaw when restored	60 or more	1524
Depth back of last molar	6.5	166
Depth at mental foramen	4.5	115
Depth near tip	5.25	133
Skull		
Width across palate at third upper molars outside	10.25	266
Width across second molars	8	204
Width of palate between molars	3	75
Width across occipital condyles	11.5	294
Diameter of foramen magnum	3.5	89
Tusk		
Measured on outer curve	79	2007
Circumference near the base	18.5	471
Greatest diameter at this point	6.25	160
Teeth		
Third upper molar, length	8.25	205
Third upper molar, width	4.25	111
Third lower molar, length	6.5	166
Third lower molar, width	3.5	99
Second lower molar, length	3.5	99
Second lower molar, width	2.5	63"

on the median line from the condyles to the broken tip of the rostrum, is 50 inches. According to the statements of those who were present when the jaw was found, not less than ten inches were broken off of the tip, and all but three fragments, each about the size of one's hand, were lost. Although actual contacts have not yet been made, the largest piece when set in place extends the length of the mandible at least three inches. The mandible originally must have been five feet or more in length. Hence it is closely comparable in length and strength to *Amebelodon fricki*. When compared with *Megabelodon lulli*, which has a long, slim, weak rostrum, that of *Gnathabelodon* seems massive and powerful."

"The tip, when restored according to instruction, was no less in width than 10 to 12 inches. This is about as wide as that of *Platybelodon grangeri*, the widest known, and fully as wide as that of *Platybelodon* [*Torynobelodon*] *barnumbrowni*."

"The condyles are very large, five inches in diameter, and each has a large process on the inner border. As established by Henry Fairfield Osborn, the ambelodonts [amebelodonts] were derived from *Phiomia* of the Middle Oligocene of Egypt. *Gnathabelodon* seems to have been in this line of ascent, and may be the final product of the amebelodonts. . . . Respecting the dentition of *Gnathabelodon*, it is a fortunate circumstance that it is practically perfect."

"The third upper molar is very large, being 8¼ inches long by 4¼ inches wide. It displays distinct [double] trefoils in the two anterior ridges and multiplied cones in the posterior. There are four grinding ridges and a well-developed heel. The valleys are abrupt and deep and all show cement. Lower molar number two is well worn and rounded. Molar three is 6½ inches long by 3½ inches wide. The two front ridges exhibit well-developed trefoils [and central conules]."

COMPARATIVE MEASUREMENTS (CF. BARBOUR AND STERNBERG, 1935)

	Gnathabelodon thorpei	*Megabelodon lulli*	*Amebelodon fricki*
Length of mandible, condyles to anterior border of rostrum	1271 mm.	1322 mm.[1]	1475 mm.
Length of mandible, when restored	1524		
Length of third inferior molar	166	222	229
Width of third inferior molar	99	89	89
Breadth-length index of third inferior molar	[60]	[40]	[39]

Habitat and Habits.—"The region may have been one of increasing aridity, in which event many creatures would of necessity have been driven for sustenance to the marshy places, where could be found grasses, sedges, and the like. If water lilies were present there would have been at hand a source of very nutritious food, for the rootstocks of pond lilies are of large size and are rich in starch, and serve even as an article of food in the dietary of man. It may be unsafe, however, to step upon the untrodden ground of palaeodietetics."

"The shovel-tuskers must have been adapted to a life more or less aquatic. In consideration of the hordes of proboscideans frequenting this part of the Great High Plains, where they were more populous perhaps than in any like area, the amebelodonts in the consequent competition for food may have sought the shallow swamps as unoccupied territory. From the start it has been assumed that *Amebelodon* and *Platybelodon* haunted the borders of streams, marshes, and ponds, and that they were shovellers of sand, mud, and soft earth, and it may be that *Gnathabelodon* was more habitually aquatic than either of the others. In any event we now know of three genera of proboscideans which in their mode of life seem to have been mud-grubbers as truly as modern elephants are browsers. In digging and shovelling the other two mud-grubbing mastodons, namely, *Amebelodon* and *Platybelodon*, had an apparent advantage in their broad, flat, mandibular tusks. In the case of *Platybelodon* these tusks were immoderately broad and had sharp cutting edges well fitted for scooping and for shearing off vegetation. *Gnathabelodon*, the great gouge-jawed proboscidean, though lacking this cutting edge of dentine, may nevertheless have continued to exercise the ancient perogative [prerogative] of the shovelling proboscideans by gouging in the softer muds with its calloused mandibular shovel. As a better adaptation for their mud-grubbing proclivities the thick hide covering the borders and tip of the rostrum may have been very callous, even corneous, thus enabling them not only to grub in sandy and muddy bottoms but, by pressure of the proboscis upon the hardened edges of the jaw, to obtain many kinds of edible herbage such as leaves, twigs, pond lilies, reeds, rushes, and the like. In addition there was at hand a variety of floating pond weeds which could be scooped up by such a gouge-shaped jaw and conveyed readily down the symphysial trough into the mouth."

"In the case of each of the three above mentioned mud-grubbing mastodons, the proboscis may have been broadened into a flange-like projection, or into a thickened pad, as indicated in the pencil sketch, so as to clamp down like a lid upon the rims of the jaw as an aid in securing and holding floating pond weeds. In this manner the floating weeds could be held in the symphysial trough, and the water strained off, and then the plants fed upon. Perhaps, as already suggested, the gnathabelodonts may have been able to tear off and devour certain plants, leaves, twigs, and the like by pressure of the broadened proboscis upon the edges of the jaw. The main dependence, however, may have been the floating pond weeds, for the interference offered by the great projecting tusks would hinder effective digging or gouging with the jaw. The upper tusks had a length of six feet and seven inches and projected a couple of feet beyond the tip of the jaw, thus interfering with mud-grubbing operations. The tusks, because of their upturned tips, may possibly have been put to good account in digging. It is a reasonable inference that the continued interference offered by the great upper tusks may have changed the feeding habits of these creatures, eventually forcing the gnathabelodonts into increasing dependence upon the more available floating pond vegetation. Altogether, *Gnathabelodon thorpei* must have been a novel, even grotesque, long-jawed mastodont with its modernized, helical tusks and its great antiquated, gouge-shaped mandible [Barbour and Sternberg, 1935, pp. 398–402]."

[1]In Chapter VIII of the present Memoir this measurement was erroneously estimated at 1504 mm.

FAMILY: BUNOMASTODONTIDÆ
SUBFAMILY: AMEBELODONTINÆ

THE SHOVEL-TUSKERS: PHIOMIA—AMEBELODON

Up to the year 1934 the progressive species of *Phiomia* from the Fayûm of North Africa were believed by Osborn to be broadly ancestral to the *Trilophodon angustidens* phylum of Europe, chiefly because of the fundamental bunomastodont pattern of the *Phiomia* molars with 'central conules' conspicuous in *Phiomia osborni*. The text of Chapter VIII was arranged accordingly, but during the years 1934, 1935 the inferior incisive tusks of *Phiomia* were sectioned and intensively compared with those of *Amebelodon* with the surprising and most welcome results graphically displayed in Plate v and Plate vi (pp. 236–237) of the present Memoir. Not only in external form but in the internal macroscopic and microscopic structure of the incisive tusks (Pl. v, A F3) *Phiomia wintoni* leads into *Phiomia osborni* and after an immense interval of geologic time spanning the Upper Oligocene, the entire Miocene, and Lower Pliocene periods, the Middle Pliocene *Amebelodon fricki* appears in Nebraska as the indubitable successor of *Phiomia osborni* of the Oligocene River Nile of Egypt. The comparative sections of the tusks (reproduced to a one-third scale in Pl. v) reveal the following determinative characters:

Phiomia wintoni, central cavity surrounded by indeterminate laminæ of dentine.

Phiomia osborni, central cavity surrounded by seven (1–7) laminæ of dentine.

Amebelodon fricki, central cavity surrounded by nine laminæ (1–9) of dentine.

This central cavity and the progressively added dentinal laminæ sharply separate off the tusks of *Phiomia—Amebelodon* from those of the *Serridentinus—Platybelodon grangeri* group (Fig. 286) in which there is no central cavity and the compact interior is filled with the dentinal rod-cones clearly represented in figures 430 and 431, page 465, of the present Volume I, and fully summarized by Colbert, as follows:

> Dentinal tubes, or more properly, *rods*, have been observed in the tusks of the following species of mastodonts:
> *Platybelodon grangeri*
> *Torynobelodon loomisi*
> *Torynobelodon barnumbrowni*
> *Platybelodon* sp. (Colo. Mus. No. 1319)
>
> Dentinal rods are *not* present in the following species:
> *Amebelodon fricki*
> *Amebelodon sinclairi*
>
> It would seem possible, then, that the presence or absence of these rods distinguishes the two subfamilies Platybelodontinæ and Amebelodontinae respectively. Thus the Texas specimen (Colo. Mus. 1319) once referred to *Amebelodon* is probably, because of the presence of these rods, a narrow-tusked *Platybelodon*. Perhaps the presence or the absence of these dentinal rods should be given more weight in making taxonomic distinctions between the two subfamilies of shovel-tuskers than the actual or relative width of the tusks. It would seem likely, also, that in the Platybelodontinæ the tusks are square across the ends, whereas in the Amebelodontinæ the ends of the tusks are rounded.
>
> Therefore the two subfamilies might be distinguished in part in the following way:
>
> | PLATYBELODONTINÆ | AMEBELODONTINÆ |
> |---|---|
> | Tusks with dentinal rods; tips square. | Tusks without dentinal rods; tips rounded. |
>
> The origin of the rods constitutes a perplexing question. To me they appear to be derived from the lamellar ivory; perhaps they represent a secondary breaking down of the concentric cones of dentine that form the tusk. Perhaps they are structures developed in the pulp cavity independently of the lamellar ivory.
>
> In *Orycteropus* there are dentinal tubules, considered by Lonnberg as secondary structures developed in the pulp cavities of the roots of the teeth. R. Anthony regards the tubules of *Orycteropus* as being homologous with the sheaths of Neumann in ordinary mammalian dentine.

The structures in the tusk of *Torynobelodon* are solid rods, I think, and not hollow tubules comparable to the tubules in *Orycteropus*. Moreover, because of their great size and irregularity, as well as because of their solid structure, it would seem likely that they are not at all homologous with the tubules in *Orycteropus*.

As mentioned above, these rods appear to me to be secondary forms, derived from the typical lamellar ivory. I doubt whether they had any real function. Possibly they were genetic characters, originating as mutations that were neither advantageous nor disadvantageous to the animal.

A magnified cross-section of a dentinal rod of *Torynobelodon loomisi* shows that it is built up of concentric layers of dentine—presumably unvascular orthodentine. An examination of the tusk of *T. loomisi* shows that the rods occupy the central portion of the tusk, and that they are surrounded by typical ivory. The rods are quite variable as to size, ranging from one to five millimeters in diameter. Many of the rods branch. There are numerous nodules or egg-shaped excrescences on the sides of various rods, and on some rods the external surface is granular. The rods are of varying lengths.

The rods are "bundled" together, so to speak, in the tusk, but they are not compressed; consequently they are round and not hexagonal. The interstices between the rods were seemingly empty; if there was a filling of dentine it has been destroyed during the process of fossilization. In many places the rods seem to grade into the lamellar ivory.

These remarkable shovel-tusks, as shown in Plate v above, not only dominate the mandible but dominate the entire skeleto-muscular frame of the Amebelodontinæ. In brief, the ivory mass of the *Amebelodon fricki* tusk is more than seventy times greater than the ivory mass of the *Phiomia osborni* tusk. As carefully estimated by Colbert (letter, March 21, 1935), the comparison is as follows:

"The end of the *Phiomia* tusk is somewhat worn; let us assume that 25 grams of ivory had been worn away before the tusk was fossilized; the amount worn away was probably less than that; but for all practical purposes we may estimate the restored weight of the *Phiomia* tusk as 150 grams, or 5.3 ounces."

The specific gravity determinations show the following results (Colbert, letter, March 21, 1935):

"Weight of *Phiomia osborni* tusk (in ivory) 125 grams 4.4 ounces
Weight of *Amebelodon fricki* tusk (in ivory) 10600 grams 23 lbs., 6.0 ounces"

"Therefore the weight of the *Phiomia* tusk as restored would be 1.4% of the weight of the *Amebelodon* tusk," or, in other words, the mass of the *Amebelodon* tusk is more than seventy times greater than the mass of the *Phiomia* tusk.

The highly differential rates of evolution of the dominantly progressive tusks of the relatively retrogressive mandibles and of the relatively arrested third superior and inferior molar teeth are shown in the following table:

DIFFERENTIAL ALLOIOMETRIC AND ARISTOGENIC EVOLUTION OF THE MANDIBLES, TUSKS, AND GRINDING TEETH OF PHIOMIA AND AMEBELODON

	Actual length of mandible, condyle to tip of rostrum	Actual length of tusks	Relative increase in length of mandible and tusks (condyle to tip of tusks)	Increase in tusk length— % of mandibular length (condyle to symphysis)	Length of grinding series—% of mandibular length (condyle to symphysis)	Length of M_3— % of mandibular length (condyle to symphysis)
Phiomia wintoni ref.	520	140	100	29 %	46 %	Unerupted
Phiomia wintoni ref.	640	180	120	31	34	10 %
Phiomia osborni type	680	250	130	33	38	11
Phiomia wintoni type	670	240e	135	35e	34	10.5
Amebelodon fricki type	1475	1144	395	54	13	12.5

The above differential measurements between *Phiomia wintoni* and *Amebelodon fricki* may be summarized as follows:

Increase in actual length of incisive tusks = + 800%

Increase in actual length of the mandible to tip of tusks = + 200%

Decrease in the relative length of the surface of the grinding series = about 30.5%

This is an outstanding example of proportional or alloiometric evolution in adaptation to a dominant habit.

Aquatic Plant Food of the 'Shovel-tuskers,' 'Flat-tuskers,' and 'Dredge-tuskers'

The wide geographic range of the Amebelodontinae from the ancient Nile River in Oligocene times to the rivers and flood-plains of Nebraska in Middle Pliocene times at once suggests that there was a parallel palaeobotanical evolution and migration both in space and time. On this point we have sought the advice of the eminent Director of the New York Botanical Gardens, Dr. Elmer D. Merrill,[1] in the following query (October 23, 1934):

"In the closing chapter of generalizations on the habits and migrations of the Mastodontoid Proboscidea, I would greatly appreciate your advice as to the probable food and feeding habits of the 'shovel-tuskers' and other types produced within the so-called division Longirostrina of the Mastodonts. That food was abundant and that the Mastodonts flourished is shown by the extraordinary evolution of the subfamily Amebelodontinae arising in the *Phiomia osborni* of the Fayûm region, Egypt, and migrating to the ancient central plains of Nebraska. Besides there are the 'flat-tuskers,' Platybelodontinae, in which the tusks are broadened and kept continually sharpened or chisel-shaped. Then there are the 'cutting-tuskers,' *Serbelodon*, a member of the Serridentine branch in which the lower tusks are of enormous size. Then there are the 'prod-tuskers,' with rodlike lower incisors terminating in long slender jaws, of the genus *Trilophodon*. Among forest dwellers in which the jaws may have reached the ground are the beak-jawed Mastodonts of the genus *Rhynchotherium*, with slender upturned lower incisive teeth."

Doctor Merrill's response is as follows (letter from E. D. Merrill, Nov. 9, 1934):

"Responding to your query regarding the possible food of the shovel-tuskers the only suggestion I can make is that probably their chief source of food was representatives of the Nymphaeaceae, the water lily family, including such genera as Nymphaea (Europe, Asia, North and South America, Africa), Nuphar (North temperate zone, Europe, Asia and North America), Nelumbium (Asia, North and South America), and perhaps Victoria (South America). Perhaps also Euryale (Asia). The family is a very ancient one, and representatives of it are still dominant in shallow marshes and lakes in Europe, Asia, Africa, and North and South America. This agrees with the geographic distribution of these ancient animals."

"As you know certain mammals feed extensively on the water lilies to-day, such as the moose and the muskrat. These plants grow in shallow fresh water in great abundance, and while the vegetative parts are eaten by various animals, such as the moose (and I think the moose also feeds on the rhizomes), the extensively developed rhizomes, or underground stems, are particularly acceptable to the muskrat. In the case of the true lotus (Nelumbium) the rhizomes are extensively utilized by the Chinese as food to-day. It may safely be assumed that the underground parts of these plants, being well supplied with starch, would be acceptable food to any herbivorous animal that could gain access to them. The rhizomes may be small as in Nuphar and Nymphaea, but are very extensive in Nelumbium, frequently several feet in length, and often as thick as one's fore-arm; this genus occurs in both North America and Asia, extending from the temperate zone into the tropics. Any large animal to gain access to the underground portions of these plants would need special adaptations to the actual digging them out of the mud, and this may explain the lower jaw development in the group you are interested in."

"I can think of no other group of marsh or fresh water lake plants where any such jaw [and tusk] development would be needed, for the reason that most fresh water aquatics, such as the pond weeds (Potamogeton) and the Hydrocharitaceae, which family contains the bulk of the fresh water flowering plants, have no underground stems, and only weakly developed root systems, usually only enough to hold the plant in place, i.e., just enough to keep them floating on the surface."

[1]Recently invited to assume the direction of the Botanical Departments of Harvard University.

Forest Dwellers. "I do not know what to suggest as the food plants for the forest dwelling [types of mastodonts, such as the Mastodontinæ: *Mastodon, Zygolophodon,* and *Turicius*] because in primary tropical forests there is almost no ground growing herbaceous plants except Zingiberaceae, which are too aromatic and too tough to be of much possible value as food for mammals, while the Araceae, found along streams in forests are usually thoroughly protected against grazing animals by having in their tissues myriads of needle-like, small, stinging crystals of oxalate of lime which are unbelievably irritating to mucous membranes, as you will know if you ever had the temerity to eat the corm of a 'Jack-in-the-pulpit' when you were a boy. . . . I think I've made a good guess at the food of the marsh and swamp dwellers, but I really don't know what to suggest for the dwellers in savannah and semi-arid areas."

The opinion of Dr. Ralph W. Chaney, former botanical expert of the Central Asiatic Expeditions of The American Museum of Natural History, is as follows (Ralph W. Chaney, 1935.1, cf. pp. 75, 85, 91–95): The following generalizations are made from the fossil plants of the Kuchu (Kutsha) on the northern side of the Tarim Basin in Sinkiang Province through the courtesy of Dr. Sven Hedin of the Sino-Swedish Expedition. The Kucha climate is that of a low rainfall. The geologic age is probably Pliocene and probably contemporaneous with the Hung Kureh. The fish remains are those of the Ameiurinae (cat fishes) now characteristic of America rather than Asia.

"Within the past seven years there have been described several genera of Proboscidea, all of which occur in beds of Pliocene or Miocene age, and are characterized by the shovel-like development of the lower jaws and teeth. [These 'shovel-' and 'flat-tuskers' evolved independently in two subfamilies, Amebelodontinæ and Platybelodontinæ. Barbour described the first of the Amebelodontinæ in south-central Nebraska as *Amebelodon fricki* (Bull. Neb. State Mus. 13, Vol. 1, pp. 131–134, text figs. 89–91, June, 1927)]. Subsequently members of the family have been recorded from the Chokrak beds of middle Miocene age in the North Caucasus by Borissiak (*Platybelodon danovi*) [Footnote: 'Ann. Soc. Paleont. Russie, Tom. VII, pp. 105–120, Pl. VII, text figs. 1 and 2, 1927.'], from the Tung Kur [Gur] formation of Pliocene age in eastern Mongolia by Osborn (*Platybelodon grangeri*) [Footnote: 'American Museum Novitates, No. 470, 1931. Recently this formation has been considered of upper Miocene age by Stirton, in Amer. Mus. Nov., No. 694, 1934.'], from the Ricardo formation of lower Pliocene age in the Mohave Desert of south-central California (*Serbelodon burnhami*) by Osborn [Footnote: 'American Museum Novitates, No. 639, June 29, 1933.'], and from various localities in the Pliocene of central Kansas and Nebraska by Barbour, including *Torynobelodon* (*Platybelodon*) *barnumbrowni* [Footnote: 'Nebraska State Museum, Bull. 22, Vol. I, August, 1931.']. In all cases these elephants [mastodonts] occur in sediments which appear to have accumulated under arid conditions."

"Commenting on the Pliocene sediments of the Iren Gobi of Mongolia, Spock has stated [Footnote: 'American Museum Novitates, No. 394, December 26, 1929.']: 'The lacustrine and fluvial beds grade into each other laterally with an imbricating and mutually overlapping contact which may well be attributed to the fluctuating size of the lakes in which the sediments of the eastern area were laid down. Apparently the Pliocene climate was characterized by marked changes in rainfall. It is worthy of note that fossils have been discovered only where there is an alternation of stream and lake deposits, and no organic remains have yet been found where there is an uninterrupted sequence of beds of the same origin. From this mode of distribution and from other supporting evidence, the fauna is believed to have had a lake-shore habitat.' "

"In the most complete statement as yet made regarding them [these mastodonts], Osborn has made the following suggestion [Footnote: 'American Museum Novitates, No. 537, June 9, 1932.']: 'With few exceptions,

Platybelodon has been found in direct association with quantities of fresh-water bivalves, suggesting that this region was at that time the shoreline of a lake of considerable extent. *Platybelodon*, with its broad flattened lower tusks, evidently found the region to its liking and very likely used its shovel-shaped jaw to scoop up succulent water plants.' "

"The occurrence in the Kucha flora of a few leaves of *Clematis*, *Rosa* and *Spiraea*, and of fruits and a leaflet of *Acer*, suggests that there were canyons sufficiently close to the lakes to permit an occasional entrance into the sedimentary record of these more sheltered members of the flora. Just how close the canyon mouths need have been it is impossible to determine in exact figures, although a distance of as much as several kilometers would probably have been sufficient to exclude from lake deposits the leaves or fruits of any of the above mentioned genera except *Clematis*, a modern species of which ranges down into the dunes bordering the lakes of Mongolia."

"The abundance of leaves of such an aquatic plant as the cat-tail (*Typha*), the numerous representation of leaves of pond-lily (*Nuphar*) at the Tieh chang kou locality, the less common occurrence of leaves of sedge (*Cyperacites*), a plant which is common today on the borders of lakes in central Asia, and of the grass (*Graminites*), indicates that deposition occurred in shallow basins occupied by water. The modern habitat of *Nuphar* and related genera shows that while it is tolerant of slightly brackish water, it does not live under conditions as saline as do *Typha*, *Cyperacites* and *Graminites*. Since these monocotyledons are more widespread than *Nuphar* in the Kucha formation, it may be assumed that the Pliocene lakes were of varying salinity. The remains of fish from Locality 51 in the Tarim Basin and of fresh-water snails at the adjacent Locality 59, corroborate the evidence of the water plants."

"The aquatic vegetation which forms so conspicuous an element of the Kucha flora probably made available an adequate supply of food over the wide area occupied by the shovel-tuskers during late Tertiary time. Stems of *Typha* and the sedges, as well as roots of *Typha* and *Nuphar* contain sufficient starch to serve as food, and must have been available in large numbers on the borders of the Pliocene lakes. Lakes and swamps are of common occurrence in the semi-arid parts of Asia and North America today, and if the climate of the Tertiary was more humid than that of today, as suggested above, they may be assumed to have been still more numerous during the Pliocene. The widespread occurrence of the shovel-tuskers, and the probability that their feeding habits were essentially as described by Osborn, serves to corroborate the evidence of the Kucha plants that lakes, occupying basins developed under semi-arid conditions, were generally distributed in central Asia during the Pliocene epoch. While many of them may have been smaller than Tsagan Nor and other modern lakes of central Asia, it seems reasonable to conclude that they were more numerous than at present, affording many situations where the Amebelodontinæ may have secured food, and where plant remains might accumulate and enter the sedimentary record."

"Aquatic plants including leaves and roots of pond-lilies (*Nymphaea*) and leaves of *Typha* are numerous in beds of upper Miocene and Pliocene age in Nevada. Leaves similar to the cat-tails and sedges represented in the Kucha flora occur in southern California in deposits somewhat younger than those in which *Serbelodon barnhami* has been found. The Pliocene Ogallala formation of Nebraska contains large stems of *Cyperus* in beds adjacent to those in which *Platybelodon* [*Torynobelodon*] *barnumbrowni* was collected. It seems possible to conclude that a food supply similar to that provided by the plants of the Kucha flora in central Asia was available for the Amebelodonts of North America, and that a generally similar topographic and climatic setting characterized extensive areas in both continents during later Tertiary time."

BREVIROSTRINÆ OF CHINA

Dr. A. Tindell Hopwood (1935.1, p. 56) gives the original references of Falconer's *Pentalophodon*, classified in the present Memoir among the Brevirostrinæ (see Chap. XIII, pp. 647–653). The following is a citation from Hopwood's Memoir (*op. cit.*, pp. 56, 57):

"This name [*Mastodon sivalensis* Cautley, genotype of *Pentalophodon*] was originally used by Falconer as indicating a theoretical stage in the evolution of the Proboscidea from *Mastodon* to *Stegodon*. He later decided that *M. sivalensis* came very close to this theoretical stage, and placed it under the sub-generic heading *Pentalophodon*. After that all specimens from India with any tendency to five ridges in the intermediate molars, and with alternating cusps, were usually grouped with *M.* (*Pentalophodon*) *sivalensis*. This led to confusion when dealing with a long series of teeth, for it is now evident that there was more than one species involved, and that not all the intermediate molars have five ridges. If, however, Falconer's original series of specimens, now in the Geological Department of the British Museum, be examined, it will be found that, with the notable exception of one skull (regd. M2877, figd. Falc. & Caut., 1847, pls. xxxii, xxxiii [=*Pentalophodon falconeri* sp. nov.]) they all show the same characters, and that the specimens which Falconer & Cautley figured in the 'Fauna Antiqua Sivalensis' as *Mastodon sivalensis* all belong to one species [of these Brit. Mus. M. 2881 (Falconer and Cautley, 1847, Pl. XXXIV, fig. 1) is referred by Osborn to *Tetralophodon* (*Lydekkeria*) (?) *falconeri* (see Chap. IX, p. 354 above) and the specimen figured by Falconer and Cautley in Plate XXXVI, figures 6, 6a is referred to *Anancus perimensis* (see Chap. XIII, fig. 617, p. 651 above)]. The confusion found in the works of later authors is largely due to the misinterpretation of Falconer's work by Lydekker (*cf.* Lydekker, 1880 [1880.1]), who included under this species other forms which Professor Osborn has separated as a distinct genus, *Synconolophus* (Osborn, 1929 [1929.797], p. 9)."

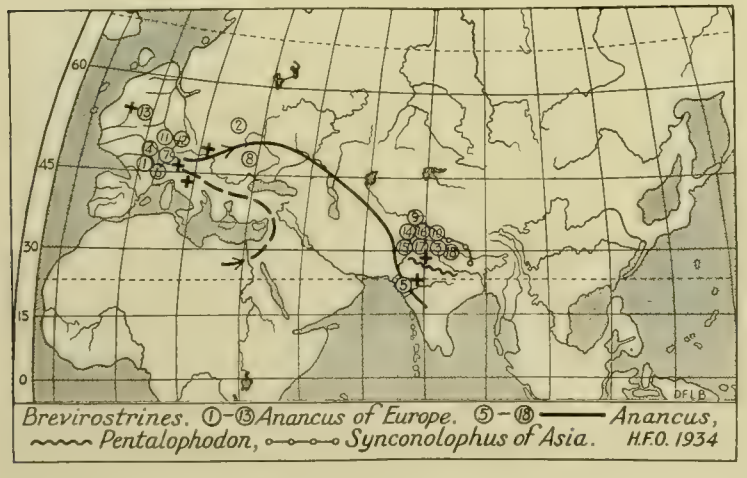


Fig. 670. Migration routes of the three phyla of Brevirostrinæ of the family Bunomastodontidæ from a hypothetic African ancestral origin to Europe and thence to India. Since this map was drawn, Hopwood (1935.1) has discovered the form *Pentalophodon* [=*Anancus*] *sinensis* in the (?)Pliocene of Shansi, China.

"Cautley's best specimen (Cautley, 1836, pl. xi, figs. 2, 3), appears to have been lost many years ago. It is not mentioned by Falconer or Lydekker, nor is it figured in the 'Fauna Antiqua Sivalensis,' so that we are deprived of the valuable information which would be afforded by a re-examination of the fossil itself, and are forced back upon the very crude figure which accompanies the paper. There does not seem to be any doubt, so far as the figure is reliable, that specimens such as that registered M. 2874 Brit. Mus. Geol. Dept. (Falc. & Caut., 1847, pl. xxxvii, figs. 8, 8a) are correctly referred, and that from them we may learn all the characters of the species."

"This is important, for the following specimen from Shansi has only four ridges in the intermediate molars, yet the third upper molar differs but little from that of *P. sivalensis*, and it is because of the agreement between the third upper molars that the specimen is referred to *Pentalophodon*."

A synopsis of this new species from China is as follows (Hopwood, 1935.1, pp. 57, 58, 59, 60):

Anancus sinensis Hopwood, 1935

Figure 671

Pentalophodon sinensis Hopwood, 1935. Plate VII, fig. 2. "Second and third left upper molars. *Holotype.*" See also figure 671 of the present Memoir.

"*Diagnosis.*—A *Pentalophodon* which is more primitive than the genotype. Intermediate molars with four ridges and a strong talon. Anterior buttress of third upper molar stronger, accessory columns not so highly developed."

"*Holotype.*—The left second and third upper molars of one individual. The second molar is extensively worn, and wear has just exposed the dentine of the first ridge of the third molar."

"*Material.*—In addition to the holotype, a left lower intermediate molar; either the fourth deciduous molar, or else the first permanent tooth, very worn."

"*Dimensions.*—

Upper Dentition	Length	Breadth	Height	Index
Holotype M2	146	83 iii	?	57
M3	216	92 iii	66 iii	42.7
Lower Dentition				
M1	114	63 iv	?	55

"Most of the details of the construction of the second molar have been destroyed; all that remains is the ground plan of the last two ridges. Those in front have disappeared almost completely. The section of the fifth cusp suggests that it was made of two cones without any accessory structures whereas the trefoil section of the seventh cusp with the relative sizes of the lobes, indicate the presence of two cones, with a third postero-internal accessory to them."

"*Discussion.*— The specimens of *P. sivalensis* used for comparison with this species were a third left upper molar (M 2857) [=*Anancus perimensis*] and a second right upper molar (40776). These were chosen as being the best preserved specimens available; the third molar is figured in the 'Fauna Antiqua Sivalensis,' pl. xxxvi, figs. 6, 6a."

"When the two species are placed side by side, it is evident that *P. sivalensis* has the shorter tooth (194 mm), and since it has a ridge formula of 6½ that the ridges are closer together than they are in *P. sinensis*. It has the accessory structures behind the inner cones of the post-trite better developed too. There is a distinct column behind the sixth cusp, and one beginning to bud off from the eighth. That is, the budding off of accessory structures has proceeded back one ridge farther in *P. sivalensis* than in *P. sinensis*. Another sign of progress is seen in the talon. This consists of three cones, instead of the single cone flanked by slight swellings of *P. sinensis*."

TYPE OF ANANCUS SINENSIS

Fig. 671. Type second and third left superior molars of *Pentalophodon sinensis* Hopwood, 1935, Pl. VII, fig. 2, one-half natural size. Observe strong alternation of internal and external cones, four ridge-crests in $l.M^2$, five to six ridge-crests in $l.M^3$. Compare with diagrammatic drawings of *Anancus properimensis* and *A. perimensis* (Fig. 609, p. 643 above), each with six ridge-crests, and *Pentalophodon falconeri* (Fig. 614, p. 646).

"*Horizon.*—Unknown: Pliocene?"

"*Localities.*—Shansi, Yü She Hsien, NW 20 li, San Chuang, NE 1 li . . . locality of holotype; Shansi, Yü She Hsien, NW 20 li, Ni Ho Chang, E 1 li, Kuan Tao Kou."

"*Description.*—The best preserved tooth is the third molar of the holotype. This has six ridges which gradually decrease in height and complexity from before backwards. All the pretrite cusps, except the eleventh, are made up of two sub-equal cones; the eleventh alone has three. Each of them, except the first, is slightly oblique to the long axis of the tooth, and has its inner cone set in advance of the inner cone of the post-trite cusp."

"The second upper molar of *P. sinensis* is so worn that comparisons between it and the corresponding tooth of *P. sivalensis* have very little value. It is evident however, that the talon was only a posterior buttress and not a fifth ridge similar to that seen in the specimen of *P. sivalensis* regd. 40776. Another specimen from India (16363) which is slightly more worn than the type of *P. sinensis*, and which formed part of Cautley's

original material (Cautley, 1836, pl. xi, fig. 11) shows quite definitely that it had five ridges, and that the pretrite cusp of the fifth ridge was oblique to the long axis of the tooth. Behind this fifth ridge are traces of a small talon."

"The lower tooth of *P. sinensis* is hardly to be distinguished from that of *P. sivalensis* except by means of its lower ridge formula. That there are no other specimens in the collection is a pity, for comparison of the unworn teeth would yield interesting differences in various points [of] detail. Such would be a comparison of the structure of the pretrite cones, or buttresses, accessory to the main cusp."

Osborn, 1935: Osborn recognizes this type as a member of the Brevirostrinæ but is inclined to place it with *Anancus*, which has four ridge-crests in the intermediate molars and five to six ridge-crests in the third molars (see Fig. 592, p. 627, this Memoir), rather than with the much more progressive *Pentalophodon*, which has five ridge-crests in the intermediate molars and six full ridge-crests and a half in the third inferior molars (see Fig. 615, p. 649, this Memoir). The type superior molar, l.M^3, in the separateness of its cones and conelets resembles the l.M_3 of *Anancus perimensis* Falconer (see Fig. 609, p. 643 of this Memoir) far more closely than it does the highly progressive and compressed molars of *Pentalophodon falconeri* Osborn (Fig. 614, p. 646). The second molar, l.M^2, has only *four* ridge-crests instead of the five generically characteristic of *Pentalophodon*.

THE NEW FAMILY HUMBOLDTIDÆ

Cuvier's two classic types of the South American Mastodonts, "Mastodonte Humboldien" and "Mastodonte des Cordilières," were first unnaturally grouped by Osborn in the subfamily Notorostrinæ Osborn, 1921, as fully described on pages 515–524, 538, 539, and 542 of Chapter XII. In 1921–1931 Osborn considered the separation of the group typified by *Cuvieronius* and *Eubelodon* from the Notorostrinæ typified by *Cordillerion*. Finally in 1934 Osborn accepted Cabrera's determination of *Stegomastodon* as a Humboldtine and in 1935 raised the subfamily Humboldtinæ (see p. 575 above) to family rank, Humboldtidæ, typified by the genus *Cuvieronius* Osborn, 1923, and including the genera *Eubelodon* Barbour, 1914, and *Stegomastodon* Pohlig, 1912. The family definition of the Humboldtidæ embraces the characters of these three genera, as follows:

HUMBOLDTIDÆ fam. nov.

Original reference: For name only, see Osborn, 1935.937, fig. 2.

Mandibular ramus abbreviating (*Eubelodon*, *Cuvieronius*) and tuskless; grinding function borne in old age by third superior and inferior molars which, from relatively simple ridge-crests (*Stegomastodon primitivus*), progress to multiple ridge-crests with double to quadruple trefoils closely compacted, enamel thick, highly ptychoid, adapted to a purely grinding function, probably inhabiting plains and uplands regions and eating the harder kinds of grassy and siliceous food in the Pampean region of South America (*Cuvieronius*) and the high plateaus of North America (*Stegomastodon*). Superior tusks progressively up- and out-turned, entirely losing enamel band, readily distinguished from the Serridentidæ of South America (*Notiomastodon*) by absence of broad enamel band and by trefoils developing primarily from the mesoconelets. Readily distinguished from the Notorostrinæ of the family Bunomastodontidæ (cf. p. 226 of Chapter VIII) by absence of central conules which are characteristic of *Cordillerion* (see Fig. 513, p. 553).

Distinctions between Cuvieronius platensis and Cuvieronius superbus

The author is greatly indebted to Director Martin Doello-Jurado of the Buenos Aires Museum for the loan to the American Museum of finely preserved mandibular rami (Buenos Aires Mus. 5213, Amer. Mus. cast 27795; Buenos Aires Mus. 44, Amer. Mus. cast 27796) which Cabrera refers respectively to *Cuvieronius platensis* Ameghino and *Cuvieronius superbus* Ameghino. These are diagrammatically represented side by side in the accompanying figure 672 to illustrate the respective characters of these two outstanding species of the Pampean of Argentina.

Referred mandible and second and third inferior molars of *Cuvieronius platensis* Ameghino, 1888. Buenos Aires Museum 5213, cast Amer. Mus. 27795. After original kindly loaned by Director Doello-Jurado. The same mandible is mentioned in Cabrera's Memoir (1929.1, p. 100) as '*Stegomastodon*' [=*Cuvieronius*] *platensis*.

It will be observed that there are five ridge-crests (I–V) and a single cone representing the rudiment of ridge-crest VI. The two anterior ridge-crests, proto- and metalophids, exhibit four conelets and double trefoils. The third crest (III) exhibits four cones and the rudiment of a single ectotrefoil; the fourth and fifth crests (IV–V) exhibit three cones only and no trefoils.

The coronoid process is extremely elevated and broad, overlapping the posterior crest of $l.M_3$; it is on the same level as the condyle.

In proposing this species in the year 1888, Ameghino (1888.1, p. 7) defined it as follows: "*Mastodon platensis*, n. sp.—The inner cusps of the upper molars and the outer of the lower, broader and worn into the shape of a trefoil leaf. Tusks not very large, straight or almost straight, and without longitudinal band of enamel, no traces of spiral.—Size a little greater than that of *Mastodon andium* and somewhat less than that of *Mastodon Humboldtii*.—Tusks as much as 2 meters long and 44 cm. in circumference at the base.—Sixth upper molar 175 mm. long and 8 ctm. wide, composed of 4 transverse cones and a posterior basal projection. Locality: Lower Pampean of the Province of Buenos Aires."

On pages 588–598 of the present Memoir, the definitions of *Cuvieronius platensis* of Ameghino, of Boule, and of Cabrera are fully cited, also the type figures of *Cuv. platensis* and of *Cuv. superbus*. The referred superior and inferior molars, from the Inferior or Middle Pampean, of *Cuv. platensis* with six ridge-crests are shown in figure 560, page 594. Simpson (page 595 of present Memoir), who studied the original collection, confirms Ameghino and Cabrera to the effect that *Cuv. platensis* has a higher number of ridge-crests; has tusks nearly straight and rather slender.

Cuvieronius platensis occurs chiefly in areas to the north and to the south of the Province of Buenos Aires.

Referred left mandible with $l.M_3$ of *Cuvieronius superbus* Ameghino, 1888. Buenos Aires Museum 44, cast Amer. Mus. 27796. After original kindly loaned by Director Doello-Jurado. This mandible was described and figured by Burmeister (1866.1, pp. 288–296, Pl. XIV) in his "Lista de los Mamiferos Fosiles del Terreno Diluviano" as *Mastodon Humboldtii*, and is reproduced on page 578 above as *Cuvieronius superbus*. The same mandible is mentioned in Cabrera's Memoir (1929.1, p. 121) as '*Stegomastodon*' [=*Cuvieronius*] *superbus*. A comparison with similar molars indicates that ridge-crests I–V probably exhibited four conelets, ridge-crests I–IV only with double trefoils. The sixth ridge-crest (VI) is represented by a single cone as in *Cuvieronius platensis*.

The coronoid process is relatively small and low, not covering the posterior ridge-crest of $l.M_3$. The condyle is relatively elevated.

In proposing this species in the year 1888, Ameghino (1888.1, p. 7) defined it as follows: "*Mastodon superbus*, n. sp.—Transverse cones of the molars worn into the shape of a thick short trefoil leaf, as in *M. Humboldtii*.—Gigantic size, greater than that of *M. Humboldtii* but less robust.—Tusks very long but proportionately slender, with little perceptible curve for the greater part of the length, but more pronounced in the anterior quarter and at its greatest near the middle; they lack all traces of spiral curving, and of an enamel band, reaching a size of 2 m. 40 long, by 53 ctm. circumference at the base.—Length of the last upper molar 24 ctm. Length of the last lower molar 27 ctm.—Femur 1 m. 10 long, but relatively slender.—Locality: Lacustrian Pampean of the Province of Buenos Aires."

Ameghino and Cabrera agree in defining *superbus* as of larger size with large, curved tusks, molars relatively short and broad with four well developed ridge-crests and rudiment of a fifth (Fig. 561, p. 594), double and highly plicated ento- and ectotrefoils on ridge-crests I–IV.

Cuvieronius superbus occurs chiefly in central areas of the Province of Buenos Aires.

From the above comparisons and from figure 672 below Osborn agrees with Simpson and Colbert that *Cuvieronius platensis* and *C. superbus* represent two different lines of specific descent; *C. platensis* is more progressive in the usually higher number of ridge-crests but less progressive in the evolution of trefoils. Consequently the molar of *C. platensis* may be more of a browsing than of a grazing adaptation. *C. superbus* is more progressive in the evolution and plication of its trefoils but less progressive in the possession of a more limited number of ridge-crests. As Colbert remarks (Colbert letter, Oct. 15, 1935): "As I see it, *C. platensis* is progressive in its elongated molar with $5\frac{1}{2}$ ridge-crests, but primitive in the single trefoils and the relatively simple enamel pattern. *C. superbus* is primitive in the shorter molar with typically $4\frac{1}{2}$ ridge-crests, but progressive in the double trefoils and the complex enamel pattern. To my mind, the development of the trefoils and the complication of the enamel folding is of more importance than the presence or absence of a ridge-crest."

As to geologic age, the two species may have been contemporaneous as in the case of the white, or grazing, rhinoceros (*Ceratotherium simum cottoni*) and the black, or browsing, rhinoceros (*Rhinoceros bicornis*) of Africa. *Cuvieronius platensis* may have ranged chiefly in partly forested or browsing areas while *C. superbus* ranged chiefly in partly grassy or grazing areas. *C. platensis* may have flourished chiefly in Lower and Middle Pampean time, while *C. superbus* flourished chiefly in Upper Pampean time.

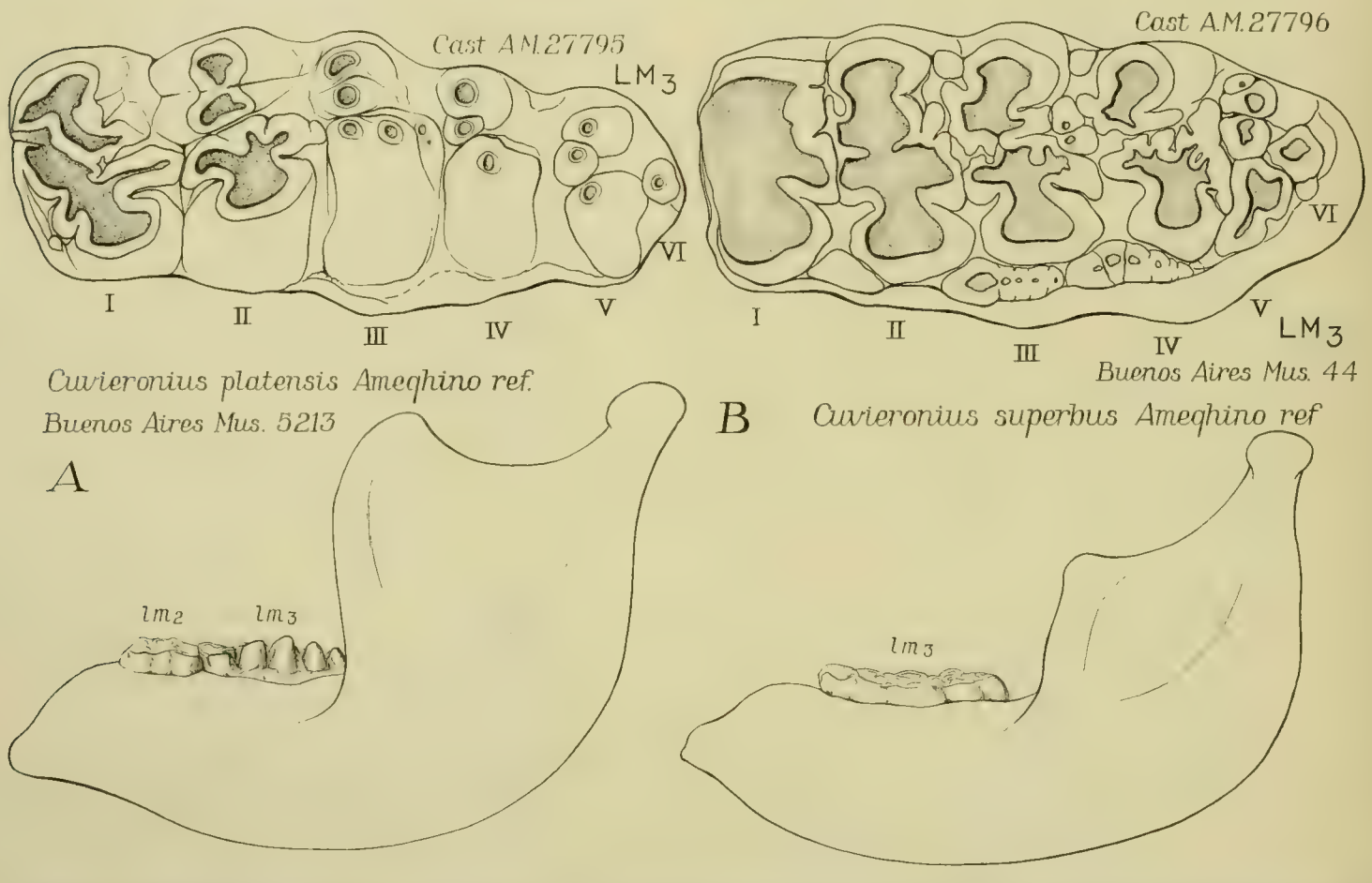


Fig. 672. Comparison of referred *Cuvieronius platensis* and *C. superbus*. Drawn from casts. Teeth less than one-half natural size; jaws about one-sixth natural size. For detailed description of these specimens, see previous page (p. 723). Description and figures of the types of *Cuvieronius platensis* and *C. superbus* will be found on pages 579 and 580 of Chapter XII above.

A NEW STEGOMASTODON

As explained above, until 1934 Osborn erroneously placed *Stegomastodon* with the Brevirostrinæ and therefore included his description of this genus in Chapter XIII. Fortunately the superb Pleistocene quarry of specimens of *Stegomastodon primitivus* opened near Ainsworth, Nebraska, was discovered in time to include the present species. This new species is surprisingly primitive and differs even from the relatively primitive *S. successor*.

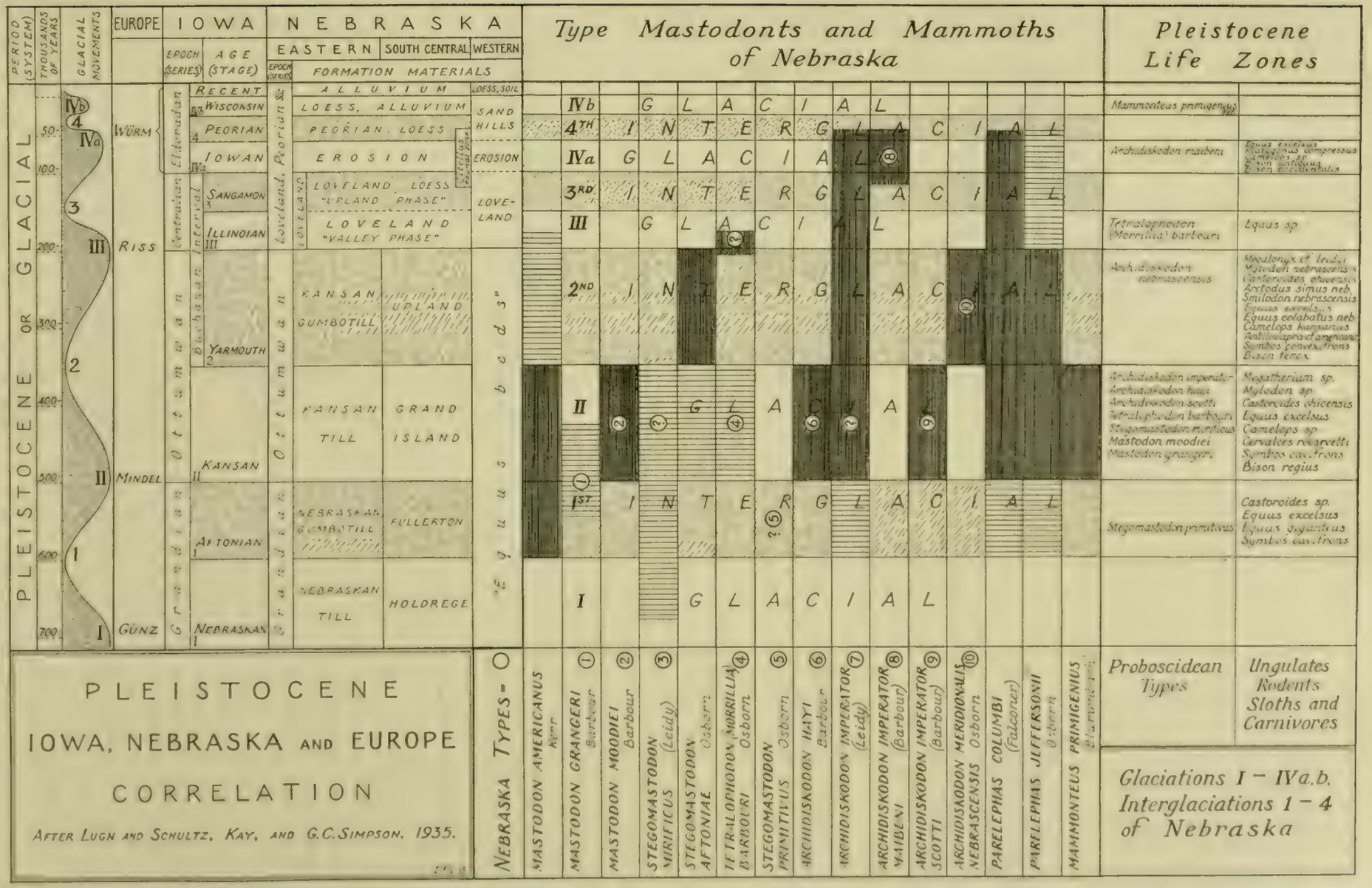


Fig. 673. Correlation chart of the Pleistocene of Nebraska, Iowa, and Europe, with certain proboscidean type localities and associated fauna. For the locality of *Stegomastodon waringi* see footnote on page 669 above; the type locality of *Stegomastodon primitivus* is, according to the discoverer of the quarry from which it came, definitely Aftonian, Lower Pleistocene (see legend to Pl. VIII).

Stegomastodon primitivus sp. nov.

Figures 674–676

Horizon.—Found in a peat bed of Lower Pleistocene (*?1st Interglacial*) age as determined by Lugn and Schultz (1934.1, p. 335), northeast of Ainsworth, Nebraska. The type palate (F.:A.M. 25000) was found by the Morris S. Skinner party of the Childs Frick Expedition of the year 1934 about seventy-five feet from the northwest corner of the main quarry. As shown in the Lugn and Schultz chart of 1935 (Fig. 673) the great *Stegomastodon primitivus* quarry lies in river deposited sands of *1st Interglacial* or Aftonian age, whereas the *S. mirificus* stage is attributed by them to the Kansan, II Glacial, while the highly specialized *S. aftoniæ* (pp. 682, 683, this Memoir) is placed by Lugn and Schultz in the Yarmouth, *2nd Interglacial*. Inasmuch as three types of *Stegomastodon*, namely, *S. successor*, *S. texanus*, and *S. arizonæ*, definitely belong in the Upper to Uppermost Pliocene, it is obvious that the geologic age both of *S. primitivus* and of *S. mirificus* demands further investigation. Type.—F.: A.M. 25000, palate with second right molar, and third molars of both sides, *in situ* in perfect state of preservation; anterior ridge-crest only worn (protoloph). Paratype.—F.:A.M. 24985, mandible containing both second and third left inferior molars. This mandible was found in the main quarry at the point indicated on the diagram (Fig.676). Type Figures.—Figure 675 A, palate with type right and left third molars; A1, paratype left third inferior molar in comparison with the type molar of *Stegomastodon mirificus* (B). All one-third natural size. Also figures 674 and 676.

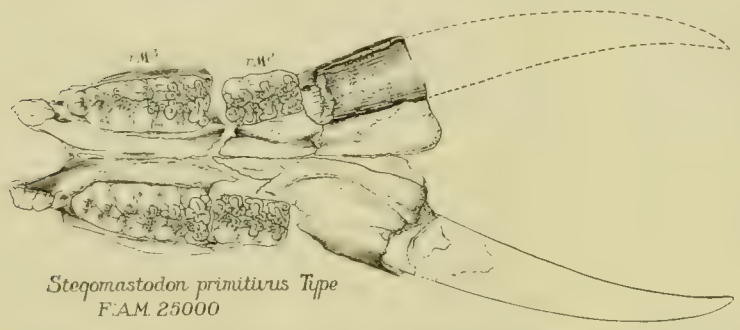


Fig. 674. Type palate and tusks of *Stegomastodon primitivus* sp. nov. from near Ainsworth, Nebraska. Tusks, r.M^3 and l.M$^{2-3}$ *in situ*, l.M^2 reversed from r.M^2. About one-tenth natural size. Original in Frick Collection of The American Museum of Natural History (F: A. M. 25000).

Type Description.—This description is based on the type palate (F.:A.M. 25000) and the paratype mandible (F.:A.M. 24985) supplemented by the numerous crania and mandibles collected in the *Stegomastodon primitivus* quarry northeast of Ainsworth, Nebraska. The second upper molar has three ridge-crests; the third has six ridge-crests, the hexaloph being rudimentary with three conelets only, in comparison with *S. arizonæ* in which the second upper molar has four to five ridge-crests[1] (see pp. 678, 679, 683, this Memoir) and the third upper molar has six plus ridge-crests. Since the definition of the six other known species of *Stegomastodon* (see synopsis above, p. 683) is based upon the primitive and progressive characters of the third superior and inferior grinding teeth, it is best to base the type description on the characters clearly displayed diagrammatically in figure 675 A, A1, in which the grinding teeth are even more primitive than those of the type of *Stegomastodon mirificus*.

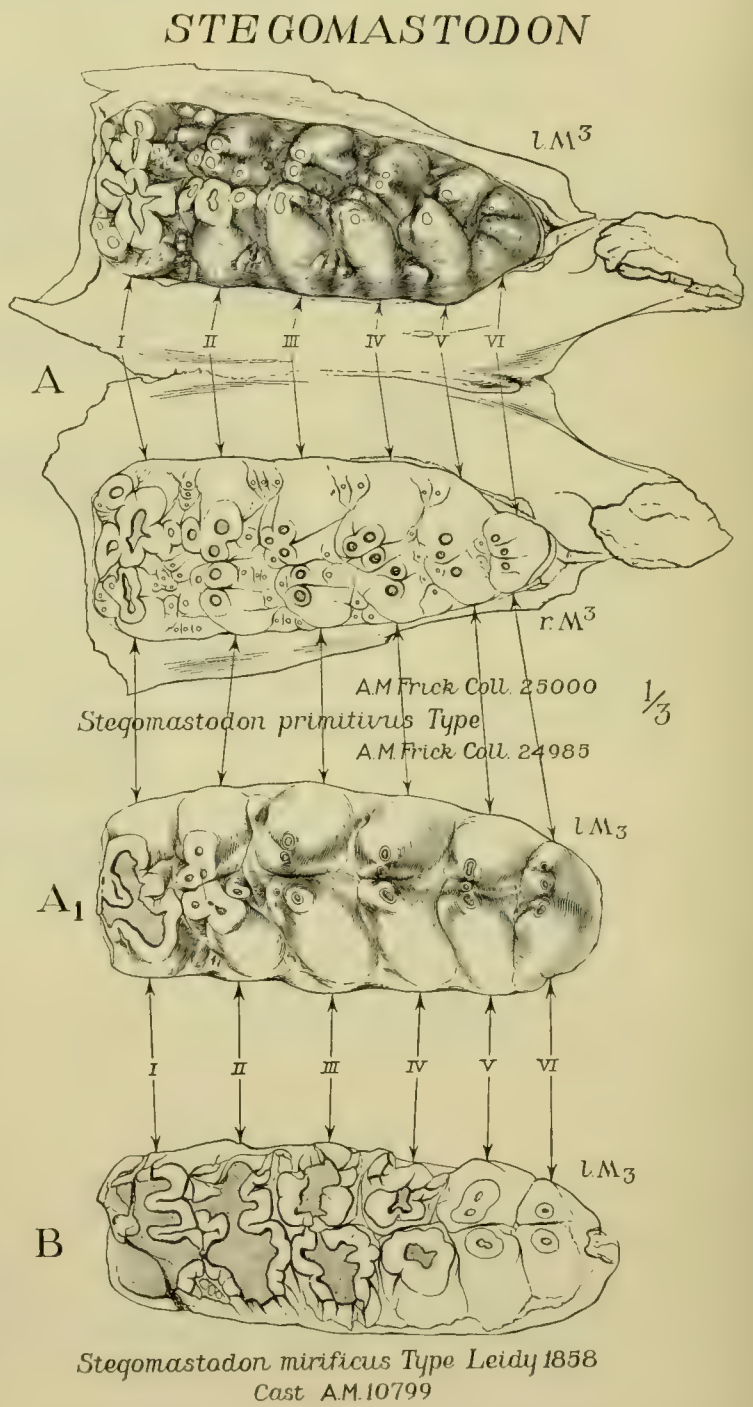


Fig. 675. Type palate (A) and paratype third left inferior molar (A1) of *Stegomastodon primitivus* sp. nov. compared with the type third left inferior molar of *Stegomastodon mirificus* Leidy (B). One-third natural size.

[1]Gidley's definition is: "Tetralophodont or nearly so . . . "

Type Description of Molars.—Type M^3 length 184 mm., width 75 mm., index 41, height at unworn fourth ridge 55 mm. Paratype M_3 length 210 mm., width 89 mm., index 42, height 70 mm. at unworn third crest. Third superior and inferior molars hexalophodont, five complete ridge-crests, sixth rudimentary ridge-crest consisting of three conelets. Single superior entotrefoils on proto- and metalophs only, rudiments of double ectotrefoils on proto- to tritolophs; double inferior trefoils on proto- and metalophids, no trefoils on trito- to hexalophids in contrast to *Stegomastodon mirificus* which has convoluted trefoils on trito- and tetartolophids. Four conelets on proto- to tetartolophs, only three conelets on penta- to hexalophs. Four conelets on proto- and metalophids; three conelets only on trito- to hexalophids of the l.M_3 of the paratype mandible. Total aristogenes, cones and conelets, on M^3, 26–29. Total aristogenes on M_3, 23. The *S. primitivus* molars are much more primitive than those of the genotypic species *S. mirificus* (Fig. 675 B) also more primitive than those of *S. successor* of the lower levels of the Blanco Pliocene (Fig. 641, p. 673, this Memoir), the next higher stage of evolution in this remarkable phylogenetic series, in which very prominent double trefoils appear on the ridge-crests of M_2 and the anterior ridge-crest of M_3. Counting the cones, conelets, and foldings of l.M_3 of *S. mirificus* we observe 33+ aristogenes as compared with 23 aristogenes in *S. primitivus* above, and 26+ in the more primitive *S. successor*.

Growth of Tusks in Stegomastodon primitivus.—In the juvenile skull (F.:A.M. 24997) the tusk is straight. In an adolescent cranium (F.:A.M. 24992) with the first and second molars in function the tusks are outwardly turned at the tips. In a young adult (F.:A.M. 24990) the tusks are somewhat inwardly turned at the tips. In the adult (F.:A.M. 24998) the tusks are quite strongly incurved at the tips. In the young adult (F.:A.M. 24994) the tusks are incurved. In the most mature and perfectly preserved cranium (F.:A.M. 24993) the tusks are sharply incurved at the tips. It seems, therefore, that during individual growth of *Stegomastodon primitivus* the tusks first projected directly out from the alveoli after which they were simply outcurved (as in F.:A.M. 24992) and then by inward rotation the tips were finally incurved at the extremities as in the following diagram. This would appear to be a progressive type of tusk growth quite different from the usual form in *S. texanus* (Fig. 642, p. 674) in which the tusks turn upwards and outwards. This sequence of tusk curvatures may be a specific distinction of *S. primitivus*.

Cabrera (1929.1, pp. 96–140) rightly associated *Stegomastodon* and certain members of Osborn's '*Mastodon*' [=*Cuvieronius*] *humboldtii* group. The species of *Stegomastodon* described and figured herein (pp. 666–684) may now be placed in the following ascending order:

ASCENDING MUTATIONS AND SPECIES OF STEGOMASTODON IN UPPER PLIOCENE AND PLEISTOCENE TIME

Lower Pleistocene[1] *Stegomastodon aftoniæ* Osborn.	M 3 heptalophodont. Ridge-crests M 3 $\frac{7\,\frac{1}{2}}{}$, hypsodont, with cement. Quadruple trefoils proto- to pentaloph, rudimentary on hexaloph. Length r.M^3 216 mm., l.M^3 222–230 mm.
Uppermost Pliocene San Pedro *S. arizonæ* Gidley.	M^2 tetralophodont plus. M 3 heptalophodont. Ridge-crests M $3\frac{6\,\frac{1}{2}}{7\,\frac{1}{2}}$. Incipient quadruple trefoils on proto-, metaloph and beyond. Length M_3 230 mm., M^3 212 mm.
Upper Pliocene Blanco *S. texanus* Osborn.	Ridge-crests M $3\frac{5\,\frac{1}{2}\text{-}6}{6\,\frac{1}{2}+}$. Quadruple trefoils proto- to hexalophid, partly sextuple. Length M^3 203 mm., M_3 223 mm.
Pliocene, *incertæ sedis*, *S. chapmani* Hays.	Imperfect type. M 3 ridge-crests unknown. Single trefoils.
(?)Upper Pliocene Nebraska *S. mirificus* Leidy. (Geologic level uncertain)[2]	M $3\frac{5\,\frac{1}{2}}{5\,\frac{1}{2}+}$, hexalophid of two cones. Double trefoils on proto- to tritolophid, rudimentary in tetartolophid, absent in pentalophid. Length M_3 222 mm.
Upper Pliocene Blanco, Lower Levels, *S. successor* Cope.	Hexalophodont, M $3\frac{5\,\frac{1}{2}}{+5\,\frac{1}{2}}$, hexalophid more rudimentary than in *S. mirificus*. Double trefoils on proto- to tetartolophids, pentalophid without trefoils. Length M_3 191+ mm.
Lower Pleistocene (*1st Interglacial*, Aftonian).	*S. primitivus* sp. nov. M^2 trilophodont. M 3 hexalophodont, primitive. M $3\frac{5\,\frac{1}{2}}{5\,\frac{1}{2}}$. Rudimentary double trefoils on proto- and metalophs, on proto- and metalophids, rudimentary single trefoils only on tritoloph, fourth to fifth crests without trefoils, tetrabunodont, sixth crest tribunodont. Length M^3 184 mm., M_3 210 mm.

[1][Lower to Middle Pleistocene. See footnote 1 on page 671 above.—Editor.]
[2][Lower to Middle Pleistocene. See footnote 1 on page 669 above.—Editor.]

As displayed in figure 673, Lugn and Schultz are quite confident that the *Stegomastodon primitivus* quarry (Fig. 676) belongs in *1st Interglacial*, Aftonian, time. This relatively high geologic position is difficult to reconcile with the fact that *S. primitivus* is in every way much more primitive than any one of the species in the Upper Pliocene of the Blanco or San Pedro (*S. successor*, *S. texanus*, *S. arizonæ*) as shown in the above ascending table. We observe that *S. primitivus* has certain peculiarities in the structure of the tusks which may remove it from the direct ancestry of the other species of *Stegomastodon* and place it in a line of its own. This important point requires further research.

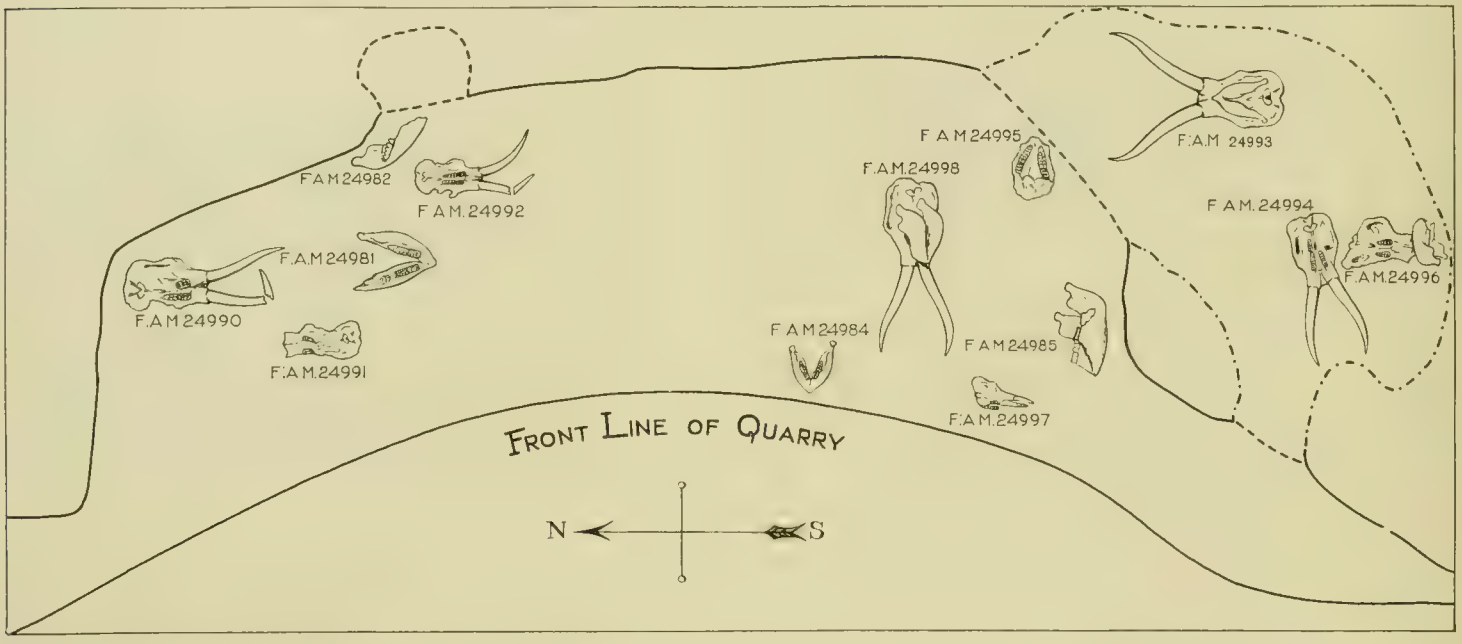


Fig. 676. Diagram of *Stegomastodon primitivus* quarry exposed by the Morris S. Skinner party of the Childs Frick Expedition of the year 1934, northeast of Ainsworth, Nebraska. The crania and palates, more or less complete but badly crushed and distorted, are shown from the original sketch by Ralph Le Roy Mefferd, modified in detail by Alastair Brown. The type palate (F.:A.M. 25000) represented in figures 674 and 675 was not found inside this quarry but about seventy-five feet beyond the northwest corner. All the specimens in this unique assemblage are identified by Colbert as belonging to the species *S. primitivus* in different stages of individual development from the extremely aged male skull (F.:A.M. 24993) to the juvenile skull (F.:A.M. 24997). The complete key to the specimens in this remarkable deposit is as follows:

F.: A.M. 24997. Juvenile skull with Dp^4(?), 3 ridge-crests. Tusk straight.

F.: A.M. 24982. Juvenile mandible. Teeth not visible due to crushing of the specimen.

F.: A.M. 24992. Juvenile skull. M^1, 3 ridge-crests; M^2, 3½ ridge-crests; M^3 undeveloped. Tip of tusk out-turned. Length, occ. cond.-symp. of prmx. 750 mm.

F.: A.M. 24981. Juvenile mandible. M_1, 3 ridge-crests; M_2, 3½ ridge-crests; M_3 undeveloped.

F.: A.M. 24990. Young adult skull. M^2, 3½ ridge-crests; anterior portion of M^3 just emerging. Tips of tusks turned inward. Length, 990 mm.

F.: A.M. 24994. Young adult skull. M^1, 3 ridge-crests; M^2, 3½ ridge-crests; M^3, 5½ ridge-crests. Tip of tusk inturned. Length, 1100 mm.

F.: A.M. 24996. Adult palate. M^3, 5½ ridge-crests. Length, 775 mm. Mandible. M_3, 5½ ridge-crests.

F.: A.M. 24995. Imperfect adult skull. Tusk in cinches, appears to turn out at tip. M^3, 5½–6 ridge-crests.

F.: A.M. 24985. Adult mandible. M_3, 6 ridge-crests. Length, 870 mm.

F.: A.M. 24998. Adult skull and mandible appressed. Tips of tusks inturned. Teeth not visible. Length, 1000 mm.

F.: A.M. 24984. Mandible. M_1, 3 ridge-crests; M_2, 4 ridge-crests; M_3 undeveloped. Length, 680 mm.

F.: A.M. 24991. Palate and teeth. M^3, 5½ ridge-crests. Length, 850 mm.

F.: A.M. 24993. The most mature skull in the quarry. Teeth not visible. Tips of tusks inturned. Mandible closely appressed on the palatal surface. Length, 980 mm.

F.: A.M. 25000. Type palate, not found within the quarry. M^2, 3 ridge-crests; M^3, 5½ ridge-crests. Estimated length, 800 mm.

THE FAMILY SERRIDENTIDÆ

Including all the 'Serrate-Toothed' Mastodonts

One of the most surprising results of the researches for the present Memoir is the wide geographic distribution and complete separation of the Serrate-toothed Mastodonts not only from the Trilophodonts but from all other mastodonts, thereby constituting a very large and highly diversified new family (cf. pp. 381, 384, 385 above) which, according to present discovery, includes no less than forty species (see List of Species at the end of this Appendix) united by the common character of the serrated crests arising from the ectoconelets in the lower molars and from the entoconelets in the upper molars; united also by the enamel bands on the superior incisive tusks which were doubtless kept sharpened and used for defensive and offensive purposes both by males and females; separated by the widely radiating adaptations of the inferior incisive tusks.

These forty species of Serridentines are grouped within seven genera, all of recent discovery and definition, as follows:

Serridentinus Osborn, 1923, typical Serridentines, including twenty-two species distributed in Colorado, California, New Mexico, Texas, Nebraska, Florida, Guatemala, China, Mongolia, Japan, India, Austria, and France.

Ocalientinus Frick, 1933, eight species from Florida, South Carolina, Kansas, New Mexico, and Mongolia.

Serbelodon Frick, 1933, three species discovered in Texas, Nebraska, and California.

Trobelodon Frick, 1933, one species from New Mexico.

Platybelodon Borissiak, 1928, 1929, two species, Mongolia and North Caucasus.

Torynobelodon Barbour, 1929, two species from Nebraska.

Notiomastodon Cabrera, 1929, two species, Argentina.

Browsers. It has been almost universally observed that the members of the Serridentidæ, especially the relatively common typical or true *Serridentinus*, do not occur in the same fossil beds with members of the Bunomastodontidæ, and the logical inference is that they had different feeding habits; the more or less perfectly serrated crests on the inner sides of the upper molars and outer sides of the lower molars point to leaf-cutting and browsing habits and give rise to the hypothesis that the typical Serridentines, at least, frequented forests and were principally browsers, while *Platybelodon* (typical flat-tusker), *Serbelodon* (cutting-tusker), and *Trobelodon* frequented shallow lakes and river borders.

The new family Serridentidæ, accordingly, may be defined as follows:

SERRIDENTIDÆ fam. nov.

Original reference: For name only, see Osborn, 1935.937, fig. 2.

Serrate-toothed Mastodonts typified by *Serridentinus serridens* (Fig. 342, p. 382) of Texas. Superior and inferior molars universally characterized by more or less perfectly developed and serrated crests springing from the ectoconelets of the inferior molars, from the entoconelets of the superior molars; a corresponding reduction and, in some species, complete disappearance of the adjacent mesoconelets, e.g., *Ocalientinus ojocaliensis* (Fig. 402, p. 434) and *Platybelodon* (Fig. 439, p. 470). Original four conelets on each ridge-crest (e.g., *Serridentinus progressus*, Fig. 369, p. 407) followed by compensatory multiplication (fission) of conelets upon the inner half of the ridge-crests of the inferior molars and the outer half of the ridge-crests of the superior molars (*Serridentinus*, Fig. 342, p. 382; *Platybelodon*, Fig. 439, p. 470). Consequent reversal of ground-plan both of the superior

molars (*Serridentinus*, Fig. 348, p. 389) and inferior molars (*Ocalientinus florescens*, Fig. 355, p. 397). Generic divergence chiefly in inferior incisors—horizontal oval in *Serridentinus*, oval greatly enlarged in *Serbelodon* (Fig. 409, p. 445), flattened into a pair of broad shovels in *Platybelodon* (Fig. 409) and abbreviated and rounded in *Torynobelodon* (Fig. 296), entirely wanting, with brevirostral mandible, in *Notiomastodon*.

Notiomastodon, a Short-jawed Member of the Serridentidæ

In Chapter XII, Section II, No. 6, of this Memoir Cabrera's genus *Notiomastodon* is described and figured (Fig. 557, p. 591); in 1934 Osborn transferred the species *Notiomastodon ornatus* and '*Mastodon*' [*Notiomastodon*] *argentinus* to the Serridentidæ.

Most generous and most influential in establishing the true phylogenetic position of *Notiomastodon* was the loan of a beautifully preserved mandible (Buenos Aires Mus. 2157; cast Amer. Mus. 27797) by the Museo Argentino de Ciencias Naturales in Buenos Aires through the courtesy of Director Doello-Jurado. This priceless mandible is most carefully figured (Pl. xii) and was also cast.

The classificatory rank of *Notiomastodon* is finally established as follows:

Superfamily: MASTODONTOIDEA Osborn, 1921
Family: SERRIDENTIDÆ fam. nov.

NOTIOMASTODONTINÆ subfam. nov.

Brevirostrine or short-jawed Serridentines, lacking inferior incisor teeth, with typically stout, abbreviated inferior mandibles. Superior incisive tusks down- and out-turned with broad enamel band as in Serridentines and Trilophodonts. Inferior molars with prominent serrated ridges arising from the ectoconelets as in Serridentines, with adjacent mesoconelets reduced or wanting, in contrast to *Cuvieronius* and *Cordillerion* in which the trefoil spurs arise from the mesoconelets.

The intensive observations of Osborn revealed the extremely important fact that *Notiomastodon* is a member of the family Serridentidæ, a relationship which rests indubitably on the fundamental structure of the grinding teeth as clearly shown in the carefully prepared drawing of the unworn second inferior molar (Fig. 557 and Pl. xii). This outstanding Serridentine character is also seen in the molars of *Serridentinus*, of *Ocalientinus*, of *Platybelodon;* it is radically different from the fundamental molar structure of any of the Bunomastodontidæ in which the trefoil structure invariably rises from the mesoconelet or is in close connection with it through the central conules. Reinforcing the Serridentine relationship is the structure of the superior tusks (Fig. 557, A, B, C, F, p. 591), laterally compressed, downcurved (see Pl. ix), provided with a broad external enamel band, all trace of which is absent in the contemporary *Cuvieronius* of the Pampean region.

Having quoted Cabrera's definition in Spanish on page 590 above, we may now present a translation[1] from Cabrera's description of 1929 (Cabrera, 1929.1, p. 90):

"Genus *Notiomastodon* gen. nov. Mastodonts with a short mandibular symphysis and no mandibular incisors, the upper incisors clearly curved at all stages, and with a lateral band of enamel, also having bunolophodont molars and the crests of the two series with accessory cusps, producing, by abrasion, a double series of trefoils. The genotype is *N. ornatus* from the Lower Pleistocene of Argentina, which I shall describe later. I consider it necessary to make a new genus of this, the only mastodont I know having these particular characters,

[1]Translated by Francesca LaMonte, April 10, 1935.

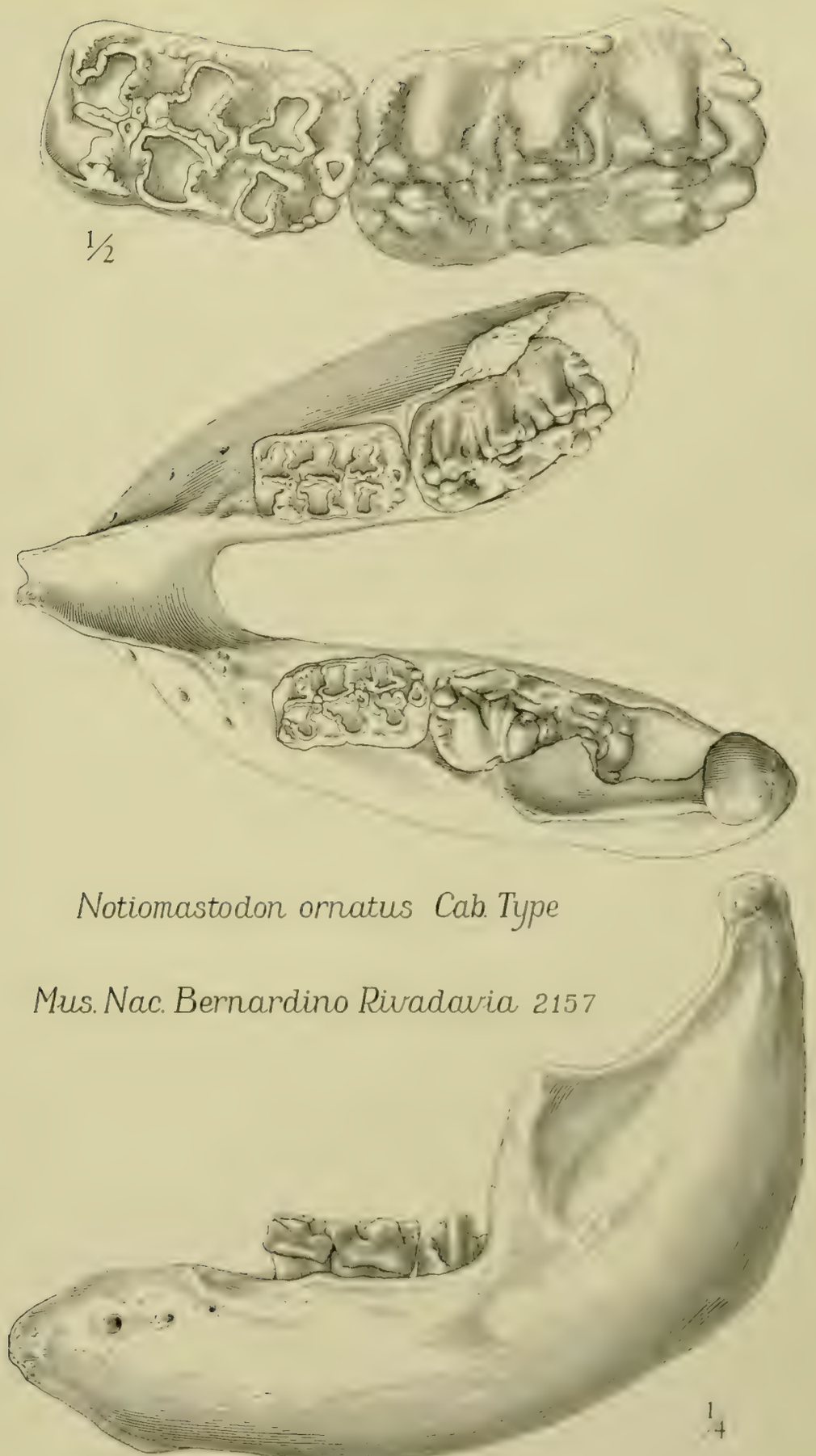


PLATE XII

Type mandible of *Notiomastodon ornatus* Cabrera, 1929, containing the first and second molars of both sides, r.M_{1-2}, l.M_{1-2}. This new type figure of *N. ornatus* is based on the type right ramus (Mus. Nac. Bernardino Rivadavia now known as the Museo Argentino de Ciencias Naturales in Buenos Aires), before reconstruction (Fig. 557, D, p. 591, of the present Memoir, after Cabrera). In the type description Cabrera identifies these molars as r.M_1 and r.M_2. (Cabrera, 1929, p. 93): "El m_1 y el m_2 son trilofodontos, con las crestas divididas en dos cúspides, como en todos los mastodontes bunolofodontos."

not having encountered among the already known genera one in which this can be included. All the other mastodonts with a band of enamel and tusks are Gomphotheriinae or Rhynchotheriinae, that is to say, they have very wide mandibular symphyses and lower incisors, with the exception of the species of the genus *Cuvieronius* [=*Cordillerion*] so characteristic in the twisted shape of its incisors and which, moreover, has different molars with truncate trefoil cusps on one side only. Gidley (1926, page 85) described under the name *Amiucus* [=*Cordillerion*] *bensonensis* a mastodont from the Pliocene of Arizona, which from the shape of its molars might well belong to this genus [i.e., *Notiomastodon*], although the appearance of its tusks is not certainly established as the author says he thinks one may attribute to it some fragments with a band of enamel coming from the same place."

Notiomastodon ornatus Cabrera, 1929
Figure 557 and Pl. XII

The superb type mandible (Buenos Aires Mus. 2157) of *Notiomastodon ornatus* was most generously loaned by Director Doello-Jurado to the American Museum for intensive research and figuring, also for the making of type casts which were deposited in the following institutions: University Museum of Zoology, Cambridge, England; British Museum (Natural History); Geological Survey of India; Munich Museum; Berlin Museum; Peabody Museum, Yale University; and the United States National Museum.

The adolescent type mandible contains the first and second inferior molars of both sides which have been figured with extraordinary fidelity by Roger Perrin Bullard, Jr., as reproduced (Pl. XII) in this Memoir. The mandible has a strongly abbreviated rostrum with a transversely concave groove for the tongue; the coronoid is small and the condyle is elevated. On the whole we never would have suspected that this animal was related to the Serridentidæ except for the identical ground-plan of the inferior molars and of the tusks.

The three ridge-crested worn first molar (M_1) illustrates the extreme difficulty of analyzing the true coronal structure from a greatly worn crown; observe at the back of the crown of M_1 and M_2 the two conelets characteristic of *Serridentinus;* observe also the broad external and internal trefoils which appear to spring from the mesoconelets but, as observed in the second molar (M_2), actually spring from the ectoconelets, for the mesoconelet is extremely reduced, especially in the protolophid of ridge-crest I.

The completely unworn second molar (M_2) exhibits in a convincing way the Serridentine relationship, namely, very prominent trefoil spurs which spring from the ectoconelets, also the extreme reduction of the mesoconelet; in ridge-crests II and III the mesoconelets are relatively larger while the trefoil spurs are relatively less prominent. Upon the inner side of the crown we perceive a pair of equal-sized conelets with less prominent development of the trefoil spurs which in this case spring from the mesoconelets.

NEW SERRIDENTINES FROM CHINA

In 1935 A. Tindell Hopwood of the British Museum (Natural History) described the species *Trilophodon wimani* which proves (Osborn, 1935) to belong to *Serridentinus*. In 1903 Schlosser described from North China, in the Röthliche Sande (see p. 384 of the present Memoir) '*Mastodon' lydekkeri* which Osborn (Chap. X, pp. 457, 458, fig. 422) recognizes as a Serridentine, *Serridentinus lydekkeri*, a very progressive stage, probably of Lower Pliocene age.

Hopwood gives as the diagnosis of *Serridentinus* a citation from Osborn (Osborn, 1923.601) which bases the genus upon the genotypic species *Serridentinus productus* Cope, *S. floridanus* Leidy, *S. obscurus* Leidy and *S. simplicidens* Osborn and cites Osborn's statement (Hopwood, 1935.1, p. 31, quoting Osborn, 1923.601, p. 2) that the genus is "'clearly distinguished from *Trilophodon* by the serrate crests ascending on the outer cones of the lower molars and on the inner cones of the upper molars; true trefoils, i.e., intermediate conules in the center of the valleys, observed in all species of *Trilophodon*, are wanting.'" Hopwood remarks (*op. cit.*, p. 31): " . . . it is not certain, however, that the 'genus' is well founded, or that it is more than a section of *Trilophodon*." This remark explains the fact that Hopwood incorrectly refers his type of '*Trilophodon*' *wimani* to *Trilophodon* rather than to *Serridentinus* to which it obviously belongs. This is explained in the following description by Hopwood, as modified by Osborn.

Serridentinus wimani Hopwood, 1935

Hopwood, 1935, Pl. v, fig. 3; also figure 677 of the present Memoir.

Trilophodon wimani, dedicated to Professor Carl Wiman, is in Osborn's opinion incorrectly referred by Hopwood to *Trilophodon* and belongs to *Serridentinus*. Hopwood observes (1935.1, p. 27):

"*Discussion.*—So far as it is possible to compare the indices of this species with those of *T. connexus*, the cheek teeth are broader in *T. wimani*. They are also larger. The fundamental difference between the two species, however, is the presence of vallecular conules in the lower dentition of *T. connexus*, and the absence of those elements from the lower teeth of *T. wimani*. Not only does this confirm the fact that the teeth are referable to separate species, but, so far as is at present known, it proves that the two species are not members of the same genetic lineage. Nor has this species any close connexion with *T.* (*Serridentinus*) *florescens* Osborn from the Pliocene Khunuk formation of Mongolia, which is regarded by its discoverer as a development of *T.* (*S.*) *mongoliensis* (Osborn, 1924a [1924.630], p. 1; 1929a [1929.797], p. 6). Neither of these species has any accessory buttresses on the post-trite cusps."

Type of Serridentinus wimani

Fig. 677. Left second and third superior molars of the type palate of *Trilophodon wimani* Hopwood. Left half of the complete palate shown in Hopwood's Memoir (Hopwood, 1935.1, Pl. v, fig. 3) showing absence of central conules and presence of tubercles on anterior faces of internal conelets of l.M³. One-half natural size.

(Hopwood, *op. cit.*, pp. 19, 20): "*Trilophodon wimani* sp. nov. (Pls. I, III, V, VI).—*Diagnosis.*—A *Trilophodon* of medium size with sub-tectiform ridges in the upper molars; pretrite cusps sub-normal in the upper, oblique in the lower, molars; post-trite cusps normal in both upper and lower molars; upper molars with strong pretrite accessory buttresses, and smaller post-trite ones; lower molars without the vallecular cones of *Tri. connexus*, but with strong pretrite, and incipient post-trite buttresses; cement fairly plentiful."

"*Holotype.*—A palate with the right first molar very worn, second molars half worn, third molars just entering into wear; the first molar on the left hand side is missing, and the right third molar has been broken off just behind the second ridge."

"*Material.*—In addition to the holotype; a left maxilla with the teeth from the second premolar to the first molar inclusive; a right second upper molar almost unworn; right mandible with the second molar worn, the third badly crushed and partly worn; a worn, broken, and crushed right first lower molar; a left second lower molar in the same condition as the preceding, and probably derived from the same individual; an isolated, worn, left second lower molar, probably derived from the same individual as the mandible; an unworn left third lower molar; three fourth premolars, two from the upper, and one from the lower jaw; one milk incisor; and fragments of two others; the tip of an adult incisor; fragments of the first, second, and third lower molars in varying states of wear; the anterior ridge of an upper molar."

"*Horizon.*—No stratigraphical details as to the age of the beds whence these fossils were derived is available, but, from their structure, one would expect tham to be of Sarmatian age. In this connexion, it is important to note that Dr. H. S. Pearson, when she described *Listriodon gigas*, the only other mammal known from Chuan Tou Kou, says that the fragments: 'show affinity with the small bunodont *Listriodon* species of the European Lower and Middle Miocene . . . ', so that we should probably not differ very much concerning the age of the beds (Pearson, 1928, p. 1)."

"Another factor which helps in determining the probable age of these teeth is their general agreement in evolutionary characters with certain undescribed teeth from the Chinji beds of the Salt Range, Punjab, India. These beds are regarded by Dr. G. E. Pilgrim as being of Upper Vindobonian age."

"*Localities.*—Kansu, Ping Fan Hsien, SE 100 li, Hsien Shui Ho E 3 li, Chuan Tou Kou; Sining Hsien from city SE 35 li, Hsin T'ien P'o N 3 li, Pa P'an Shan. The latter is the locality of the holotype." The dimensions by Hopwood (with some omissions) are as follows:

	Upper Dentition		Length	Breadth	Height	Index
Holotype.	Left	M2	107	67 iii	51 iii	62.6
		M3	151	72 ii	62 ii	47.7
	Right	M2	103	65 iii	49 iii	63.1
		M3	?	69 i	63 ii	——
	Lower Dentition					
[Referred]	Isolated M3		185	75 ii	67 ii	45.4

Osborn, 1935: Osborn refers the type palate of *T. wimani* to the genus *Serridentinus* because of the absence of central conules and the presence of characteristic serrated spurs on the entoconelets of the superior molars (Fig. 677), also serrated spurs on the ectoconelets of the referred left third inferior molar l.M³ (Hopwood, *op. cit.*, Pl. VI, fig 1). As remarked below, Hopwood's '*Trilophodon*' *wimani* is closest in measurement and in its primitive charcters to *Serridentinus subtapiroideus* of the Helvetian and *Serridentinus browni* of the Lower Chinji.

Serridentine Relationship.—As indicated by Hopwood (*op. cit.*, p. 27) the types of *Trilophodon wimani* are much more primitive than the Pliocene *Serridentinus florescens* Osborn of Mongolia. In the molar types they are rather comparable to the *Serridentinus subtapiroideus* Schlesinger of Eibiswald in Steiermark or to the blunt-coned type of *Serridentinus browni* Osborn, 1926, from the Lower Chinji horizon, 800 feet above the base of the Lower Siwaliks, India (see pp. 452 and 453, fig. 416).

	ap.	tr.	I.	Height	Ridge-crests
Serridentinus subtapiroideus Schles., cotype M^3	150	83	55	..	4
Serridentinus wimani Hopwood, type $l.M^3$	151	72	47.7	64	4 and talon
Serridentinus browni Osborn, type M^3	162	80	49	..	4⅛–⅓

(See table of measurements and indices on page 455 of this Memoir.)

SERRIDENTINE OF NORTH AMERICA

Ocalientinus emmonsi Hay, 1930

From marl beds of Halifax County, North Carolina. Miocene [Pliocene on p. 385 of the present Memoir].

Gomphotherium? *emmonsi* Hay, 1930. "Second Bibliography and Catalogue of the Fossil Vertebrata of North America," Vol. II, p. 636. TYPE.—A second superior molar of the left side, $l.M^2$, described as an $r.M_1$ of *Mastodon giganteus* by Emmons (*fide* Ebenezer Emmons, "Report of the North-Carolina Geological Survey," 1858, p. 198). HORIZON AND LOCALITY.—Marl beds of Halifax County, North Carolina. What Emmons termed the "miocene marl of North-Carolina" is, according to Colbert (letter, Oct. 18, 1935), "the *Duplin* marls belonging to the Yorktown formation. The Yorktown formation is of Miocene age and is predominantly of marine origin. . . Hay placed *Gomphotherium*? [*Ocalientinus*] *emmonsi* in the (?)Pleistocene (which is extensively exposed in North Carolina)." TYPE FIGURE.—Ebenezer Emmons, "Report of the North-Carolina Geological Survey," 1858, p. 199, fig. 23, and "Manual of Geology," 1860, p. 218, fig. 186; see also figure 678 of the present Memoir.

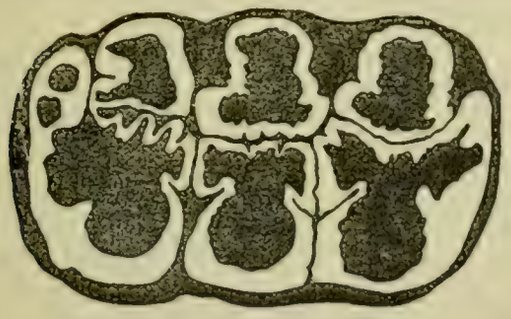


Fig. 678. *Ocalientinus emmonsi*. Type $l.M^2$ of *Gomphotherium*? *emmonsi* Hay, 1930. After Emmons, 1860.1, fig. 186, p. 218; see also Emmons, 1858.1, fig. 23, p. 199.

EMMONS' DESCRIPTION.— (Emmons, 1858.1, pp. 198–200): "Proboscedians.— Mastodon giganteus.— (Fig. 23). The bones of this large pachyderm are not uncommon in the miocene marl of North-Carolina. Fragments of ribs and bones of the extremities are most common. The figure of the superior part of the crown in the margin was taken from a tooth found in Halifax county. Its enamel is jet black and highly polished. It is the first or small molar of the right side of the under jaw. It is an old tooth with the lubercles [tubercles] worn down, and was probably lost or shed while the animal was living. The figure is designed to show the arrangement of the enamel plates."

In 1860 Emmons ("Manual of Geology") refigured this molar, p. 218, fig. 186, also molars of the horse and of *Oreodon culbertsoni*.

Leidy (1869.1, p. 396) referred this specimen to *M. obscurus*.

Hay (1930) did not describe the species '*Gomphotherium*?' *emmonsi* but referred only to Emmons' "Report of the North-Carolina Geological Survey" of 1858.

Osborn, 1935: The type molar of '*Gomphotherium*?' *emmonsi* Hay compares most closely with the first right superior molar of *Ocalientinus* (*Serridentinus*) *floridanus* as shown in figure 379 C, page 417, of this Memoir, from the Alachua clays of Florida, now regarded as of Lower Pliocene age. The type of *Ocalientinus emmonsi* is, however, clearly distinguishable specifically from, and apparently more progressive than, either the right or left first superior molars referred to *Ocalientinus* (*Serridentinus*) *floridanus*. This type molar should also be compared with the anterior portion of an $l.M^1$ of *Ocalientinus* (*Serridentinus*) *floridanus leidii* Frick as shown in figure 381, page 419, of this Memoir.

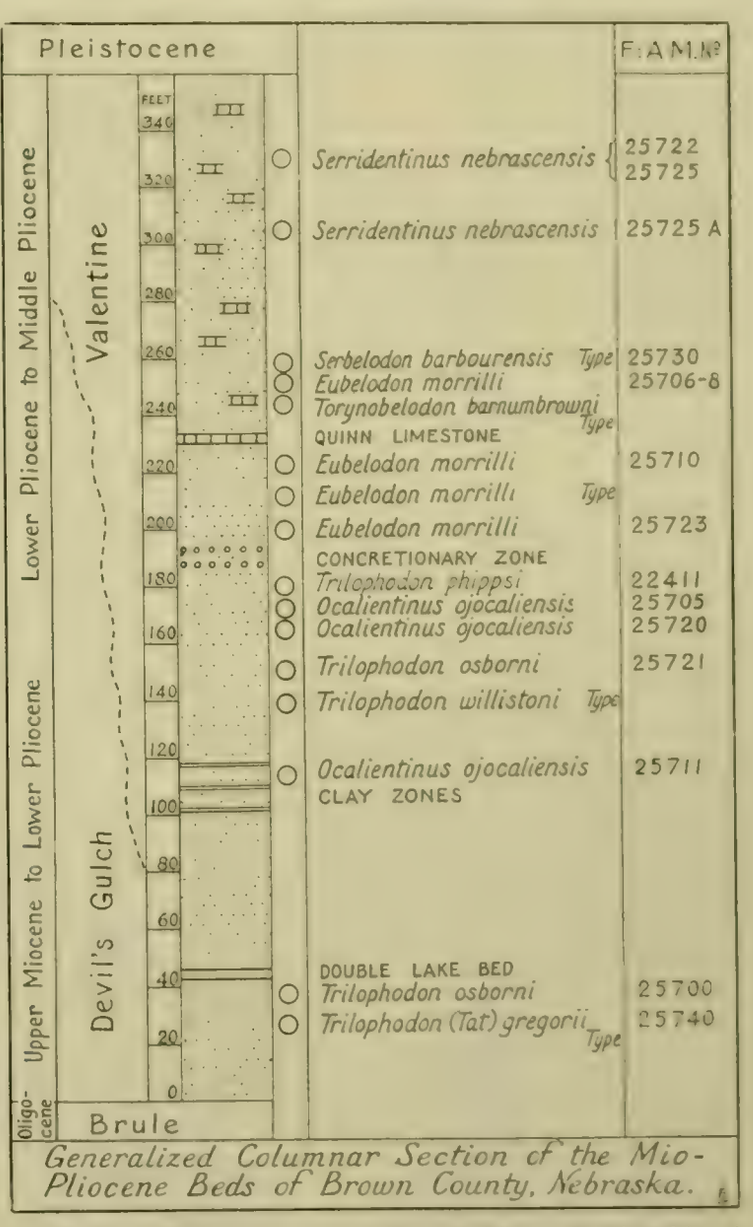


Fig. 679. This columnar section of the Mio-Pliocene Devil's Gulch and Valentine region of Nebraska is a duplication of figure 272, Chapter VIII, above, with important corrections of the catalogue numbers and changes in the determination of genera and species. While this section is not germane to the text of the Appendix, it is inserted here, so that the valuable new information it embodies may be available to the reader.

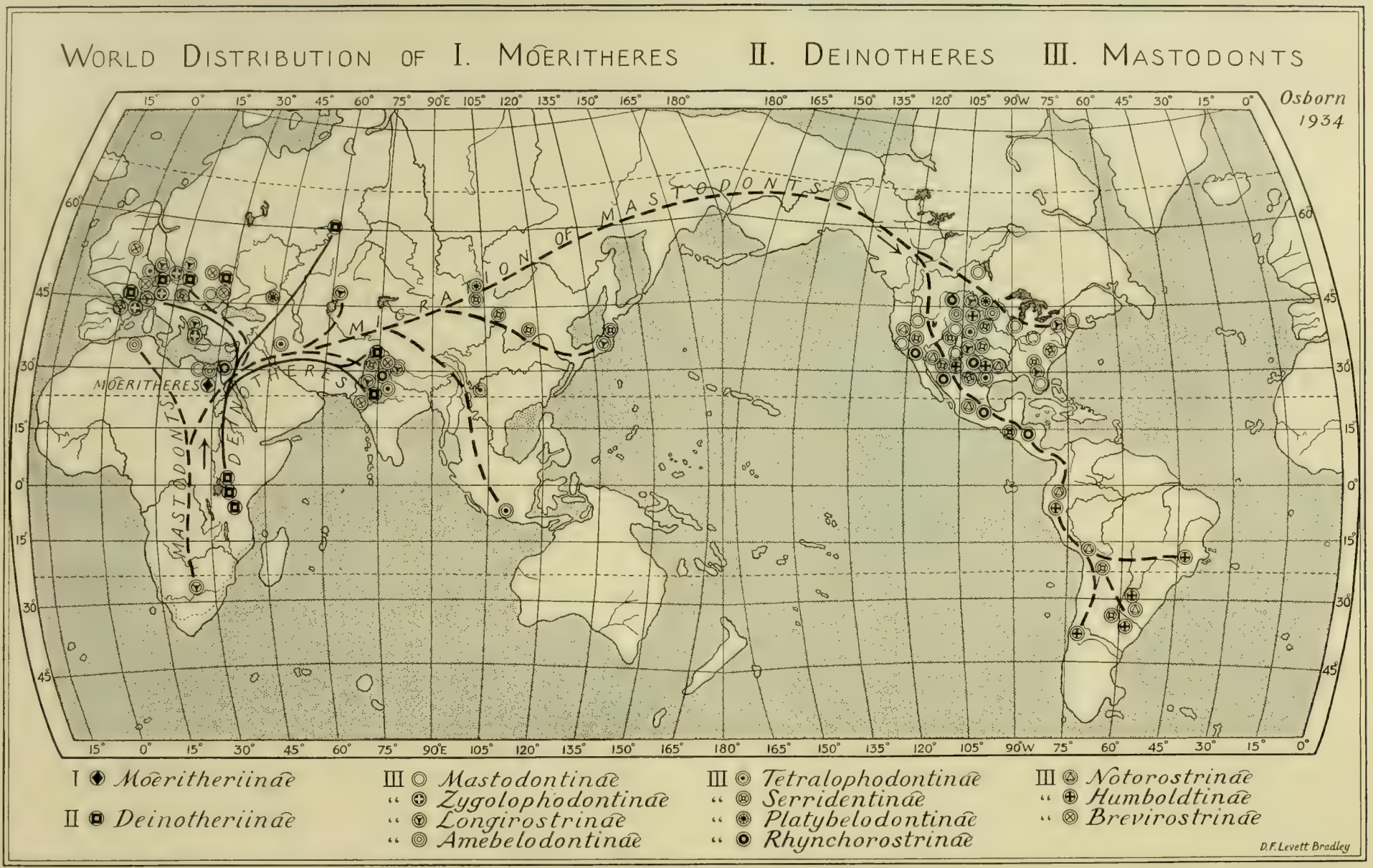


Fig. 680. Geographic distribution of three of the great primary stocks of the Proboscidea, namely, the Mœritherioidea, Deinotherioidea, and Mastodontoidea. This map, the result of intensive research by the present author over a period of more than thirty years, illustrates the theory put forward in 1899–1900 by Tullberg, Stehlin, and Osborn that Africa was the continent on which the Proboscidea originated (see Chap. II, p. 34, also Fig. 6, above).

OSBORN'S FINAL (1935)
CLASSIFICATION OF THE MŒRITHERIOIDEA, DEINOTHERIOIDEA, AND MASTODONTOIDEA

The classification of the families and subfamilies of Proboscidea first adopted by Osborn (1933) will be found on pages 30 to 32, Chapter II, above, and includes the Mœritherioidea, Deinotherioidea, Mastodontoidea, Stegodontoidea (p. 22, footnote), and Elephantoidea.

The following classification of 1935 is somewhat more comprehensive, in that it includes the genera and species adopted in the present Volume I (exclusive of the Stegodontoidea and Elephantoidea which will be treated in Volume II), and demonstrates in conjunction with figure 680 on the opposite page the wide geographic range of these proboscideans. The geologic range is graphically displayed in the phylogenetic charts (Pls. x and xi) of the years 1934 and 1935 respectively.

Superfamily: MŒRITHERIOIDEA

Fam.: MŒRITHERIIDÆ. Subfam.: MŒRITHERIINÆ

Genus: *Mœritherium*

Primitive aquatic Proboscideans, Hippopotamus-like, or Sirenian-like bodies

MŒRITHERIUM Andrews, 1901		Page
Mœritherium andrewsi Schlosser, 1911, Fayûm, Egypt, Fluvio-marine formation	Lower Oligocene	61, 74
Mœritherium trigodon Andrews, 1904, Fayûm, Egypt, Fluvio-marine formation	Lower Oligocene	57, 74
Mœritherium lyonsi Andrews, 1901, Fayûm, Egypt, Qasr-el-Sagha formation	Upper Eocene	54, 72
Mœritherium gracile Andrews, 1902, Fayûm, Egypt, Qasr-el-Sagha formation	Upper Eocene	56, 73
Mœritherium ancestrale Petronievics, 1923, Fayûm, Egypt, Qasr-el-Sagha(?) formation	Upper Eocene	65, 76

Superfamily: DEINOTHERIOIDEA

Fam.: CURTOGNATHIDÆ. Subfam.: DEINOTHERIINÆ

Genus: *Deinotherium*

Very large downturned inferior tusks, no superior tusks; elephantine bodies

DEINOTHERIUM Kaup, 1829. Partial list of species		
Deinotherium hopwoodi sp. nov., Olduvai, southeast shore Lake Victoria, Africa	Middle Pleistocene	117
Deinotherium gigantissimum Stefănescu, 1892, Găiceana, Rumania	Lower or Middle Pliocene	95
Deinotherium indicum Falconer, 1845, Perim Island, India	Middle Pliocene	90, 105, 114
Deinotherium giganteum Kaup, 1829, Eppelsheim, Germany	Lower Pliocene	80, 84, 86, 114
Deinotherium uralense Eichwald, 1835, Ural Mountains	Lower Pliocene	85, 87, 114
Deinotherium podolicum Eichwald, 1835, Podolia, Russia	Pliocene (?)	85, 87
Deinotherium intermedium De Blainville, 1845, France	Upper Miocene (?)	85, 90, 115
Deinotherium bavaricum von Meyer, 1831, Gmünd, Bavaria	Upper Miocene	84, 99, 107, 115
Deinotherium hungaricum Éhik, 1930, Kotyháza, Hungary, Burdigalian (?)	Lower Miocene (?)	115, 116
Deinotherium indicum gajense Pilgrim, 1912, Bugti Hills, Baluchistan, Bugti beds	Lower Miocene	85, 105, 115
Deinotherium cuvieri Kaup, 1832, Chevilly, France	Lower Miocene	85, 87, 90, 107, 115
Deinotherium hobleyi Andrews, 1911, Karungu, British East Africa	Lower Miocene	104, 115

Superfamily: MASTODONTOIDEA

Fam.: MASTODONTIDÆ. Subfam. nov.: PALÆOMASTODONTINÆ

Genus: *Palæomastodon*

Superior tusks unknown; inferior tusks short, rounded. Progressive grinders, with six cones, proto- and metaconules closing the median sulcus. Not ancestral to Mastodontinæ

PALÆOMASTODON Andrews, 1901		
Palæomastodon beadnelli Andrews, 1901, Fayûm, Egypt, Fluvio-marine formation	Lower Oligocene	54, 147
Palæomastodon intermedius Matsumoto, 1922, Fayûm, Egypt, Fluvio-marine formation	Lower Oligocene	63, 146
Palæomastodon parvus Andrews, 1905, Fayûm, Egypt, Fluvio-marine formation	Lower Oligocene	59, 146

Fam.: MASTODONTIDÆ. Subfam.: MASTODONTINÆ

Genera: *Miomastodon, Pliomastodon, Mastodon*

Superior and inferior tusks rounded, enamel disappearing; typical mastodontine bodies

Species of Eurasia and North America in approximate theoretic descending order, apparently monophyletic, directly ancestral to typical *Mastodon*

MASTODON Cuvier, 1806, 1817. Superior tusks without enamel; molars with median sulcus and progressively sharpened crests		Page
Mastodon acutidens sp. nov., Rochester, Indiana	Pleistocene—Postglacial (IV)	696
Mastodon americanus alaskensis Frick, 1933, near Fairbanks, Alaska	Pleistocene	176
Mastodon oregonensis Hay, 1926, Rye Valley, Baker County, Oregon	Pleistocene (?)	173
Mastodon americanus plicatus Osborn, 1926, Walnut, Bureau County, Illinois	Late Pleistocene—Postglacial (IV) or post-Wisconsin (?)	173
Mastodon americanus rugosidens Leidy, 1890, Beaufort County, South Carolina	Pleistocene	171
Mastodon raki Frick, 1933, Hot Springs, New Mexico	Pleistocene	175
Mastodon americanus rupertianus Richardson, 1854, Lake Winnipeg basin, Manitoba, Canada	Pleistocene	137
Mastodon americanus Kerr, 1792, Big-Bone Lick, Boone County, Kentucky	Late Pleistocene (IV Glacial = Wisconsin time)	170
Mastodon grangeri Barbour, 1934, Pender, Thurston County, Nebraska	Pleistocene (*1st Interglacial*, Aftonian, or II Glacial)	175, 695
Mastodon moodiei Barbour, 1931, near Milford, Seward County, Nebraska	Pleistocene (II Glacial)	174
Mastodon progenius Hay, 1914, Missouri Valley, Harrison County, Iowa	Early Pleistocene	172
Mastodon pavlowi sp. nov., Pestchana, Podolia, Russia	Pleistocene	694
PLIOMASTODON Osborn, 1926. Superior tusks with enamel; molar crests intermediate in character (subhypsodont)		
Pliomastodon vexillarius Matthew, 1930, near Coalinga, Fresno County, California	Late Pliocene	161
Pliomastodon americanus praetypica Schlesinger, 1919, 1922, Batta-Érd, Hungary	Middle Pliocene	159
Pliomastodon sellardsi Simpson, 1930, Brewster, Florida, Bone Valley formation	Lower Pliocene	160
Pliomastodon matthewi Osborn, 1921-1926, Snake Creek B, Sioux County, western Nebraska	Lower Pliocene	157
MIOMASTODON Osborn, 1922. Superior tusks with enamel; molars with rounded crests		
Miomastodon tapiroides americanus Schlesinger, 1921, 1922, Tasnád, Hungary	Lower Pliocene	156
Miomastodon merriami Osborn, 1921, Thousand Creek, Humboldt County, Nevada, Virgin Valley formation (type)	Middle Miocene	154
Pawnee Creek horizon, Colorado (ref.)	Middle Miocene	155
Miomastodon depereti sp. nov., Chevilly, Sables de l'Orléanais, France	Lower Miocene	693

Fam.: MASTODONTIDÆ. Subfam.: ZYGOLOPHODONTINÆ

Genera: *Zygolophodon, Turicius*

Mastodontoid molar crowns, valleys open, conelets progressively added

ZYGOLOPHODON Vacek, 1877. Molars transversely crested, conelets 4–6, valleys open, median sulcus disappearing		
Zygolophodon borsoni zaddachi Jentzsch, 1883, Thorn, west Prussia	Upper Pliocene	209
Zygolophodon borsoni Hays, 1834, near Villanova, Asti, Piedmont, Italy (type); western Eurasia (ref.)	Middle to Upper Pliocene	207
Zygolophodon pyrenaicus Lartet MS. (in Falconer, 1857), Lartet, 1859, Ile-en-Dodon (Haute-Garonne), France (type)	Middle Miocene	206
Zygolophodon pyrenaicus aurelianensis Osborn, 1926, Sables de l'Orléanais, Chevilly (?), France	Lower Miocene	207
TURICIUS Osborn, 1926. Molars transversely crested, conelets 4–25, valleys open, median sulcus disappearing		
Turicius wahlheimensis Klähn, 1922, Wahlheim and Esselborn, Rheinhessen, Germany	Pliocene	282
Turicius virgatidens von Meyer, 1867, Fulda, northeast of Frankfort, Germany, 'Gelben Lehme'	Middle (?) Pliocene	221
Turicius atticus Wagner, 1857, Pikermi, Greece	Lower Pliocene	220
Turicius turicensis Schinz, 1824, Elgg, Canton Zurich, Switzerland, Tortonian	Upper Miocene	219
Turicius turicensis simorrensis Osborn, 1926, near Simorre (Gers), France	Upper Middle Miocene	219
Turicius tapiroides Cuvier, 1806, 1821–1824; (in Desmarest, 1820–1822), Calcaire de Montabusard, France	Lower Miocene	217

Fam.: MASTODONTIDÆ. Subfam. nov.: STEGOLOPHODONTINÆ

Genus: *Stegolophodon*

Stegodontoid rounded molar cones, valleys compressed; median sulcus persisting in anterior crests

			Page
STEGOLOPHODON Schlesinger, 1917. Molars transversely crested, conelets 4–5+.			
Stegolophodon stegodontoides Pilgrim, 1913, Lehri, Punjab, India, Upper Siwaliks (?)	Upper (?) Pliocene	Pl. IV, I,	701
Stegolophodon cautleyi Lydekker, 1886, Perim Island, India	Middle Pliocene	Pl. IV, H,	701
Stegolophodon sublatidens Schlesinger, 1917, Teschen (Schlesien), Austria	Middle (?) Pliocene	Pl. IV, A	
Stegolophodon lydekkeri sp. nov., Bruni, northwest Borneo	Pliocene (?)	Pl. IV, G,	700
Stegolophodon latidens Clift, 1828, near Yenangyaung, Irrawaddy River, Burma, Irrawaddy Series (fluviatile)	Lower Pliocene	Pl. IV, D,E,F,	701
Stegolophodon nathotensis Osborn, 1929, Nathot, Lower Middle Siwaliks, India, Lower Chinji horizon	Mio-Pliocene	Pl. IV, C	
Stegolophodon cautleyi progressus Osborn, 1929, near Chinji Bungalow, summit of Lower Chinji, 2,000 feet above base of Lower Siwaliks, India	Mio-Pliocene	Pl. IV, B	

Fam.: BUNOMASTODONTIDÆ. Subfam.: RHYNCHOROSTRINÆ

Genera: *Rhynchotherium, Blickotherium, Aybelodon*

Typical beak-jawed Mastodonts. Mandible strongly deflected; enamel band on superior and inferior incisive tusks (except in *Aybelodon*), inferior tusks upturned; molars with variable central conules, enamel thick, few ridge-crests (4–5)

RHYNCHOROSTRINES OF THE WESTERN UNITED STATES AND MEXICO

		Page
RHYNCHOTHERIUM Falconer, 1856 (MS.), 1863, 1868		
Rhynchotherium falconeri Osborn, 1923, Mt. Blanco, Staked Plains, Texas	Upper Pliocene	494
Rhynchotherium shepardi edense Frick, 1921, Mt. Eden Hot Springs, San Bernardino County, California	Upper Pliocene	496
Rhynchotherium browni sp. nov., San José de Pimas, Sonora, Mexico	Upper Pliocene	494
Rhynchotherium tlascalæ Osborn, 1918, 1921, Tlascala, Valley of Mexico	Upper(?) Pliocene	493
(?)*Rhynchotherium francisi* Hay, 1926, Brazos River, Pittbridge, Burleson County, Texas	Pliocene(?)	501
Rhynchotherium anguirivale Osborn, 1926, Snake Creek B, Sioux County, Nebraska	Lower Pliocene	491
Rhynchotherium rectidens Osborn, 1923, near Pawnee Buttes, Weld County, Colorado, Pawnee Creek horizon	Upper Miocene	488
Rhynchotherium shepardi Leidy, 1871, Dry Creek, Stanislaus County, California	Upper(?) Miocene	487
Rhynchotherium brevidens Cope, 1889, Smith River, Meagher County, Montana, Deep River horizon	Middle to Upper Miocene	485

RHYNCHOROSTRINES OF ASIA AND AFRICA

		Page
Rhynchotherium chinjiense Osborn, 1929, near Chinji Bungalow, India, 600 feet above base of Lower Siwaliks	Mio-Pliocene	502
Rhynchotherium spenceri Fourtau, 1918, Moghara Desert, northern Egypt	Middle Miocene	485

RHYNCHOROSTRINES OF CENTRAL AMERICA

		Page
BLICKOTHERIUM Frick, 1933. Mandible progressively slender; incisors with enamel		
Blickotherium blicki Frick, 1933, near Tapasuma, Honduras	Pliocene	508
Blickotherium euhypodon Cope, 1884, Driftwood Creek, Hitchcock County, Nebraska, Republican River beds	Lower Pliocene	489
AYBELODON Frick, 1933. Mandible attenuate; inferior incisors without enamel		
Aybelodon hondurensis Frick, 1933, near Tapasuma, Honduras	Pliocene	509

Fam.: BUNOMASTODONTIDÆ. Subfam.: LONGIROSTRINÆ

Genera: *Trilophodon, Megabelodon*

Intermediate molars trilophodont (3 crests); third molars with 4–5+ crests and *central conules*. Superior tusks flattened, recurved, with enamel band; inferior tusks rounded, triangular, flattened-horizontal, flattened-oblique, massive, sometimes absent. Mandible hyperlongirostral

TRILOPHODON OF EURASIA AND AFRICA

		Page
TRILOPHODON Falconer, 1846, 1857		
Trilophodon hasnotensis sp. nov., near Hasnot, India, 1,000 feet below Bhandar bone bed (= Dhok Pathan horizon)	Middle Pliocene	279
Trilophodon esselbornensis Klähn, 1922, Esselborn, Westhofen, Rheinhessen, Germany	Pliocene	281
Trilophodon (*Choerolophodon*) *pentelicus* Gaudry and Lartet, 1856–1862, Pikermi, Greece (type)	Lower Pliocene	263
Samos Island (ref.)	Lower Pliocene	264

		Page
Trilophodon sendaicus Matsumoto, 1924, Kitayama, near Sendai, Province of Rikuzen, Japan	Lower Pliocene	280
Trilophodon connexus Hopwood, 1935, Kansu, China	Miocene	702
Trilophodon spectabilis Hopwood, 1935, locality and horizon unknown		702
Trilophodon inopinatus Borissiak and Beliaeva, 1928, Jilančik beds, Turgai region, Central Asia	Miocene	278
Trilophodon angustidens var. *libycus* Fourtau, 1918, Moghara, northern Egypt, Africa	Lower(?) Miocene	260
Trilophodon macrognathus Pilgrim, 1913, near Chinji, India, Upper Chinji	Mio-Pliocene	274
Trilophodon chinjiensis Pilgrim, 1913, Osborn, 1932, near Chinji Bungalow, Lower Chinji	Mio-Pliocene	272
Trilophodon angustidens gaillardi Osborn, 1929, Villefranche d'Astarac (Gers), France	Upper(?) Miocene	259
Trilophodon engelswiesensis Klähn, 1922, Engelswies, Baden, Germany	Miocene	281
Trilophodon steinheimensis Klähn, 1922, Steinheim, Baden, Germany	Middle to Upper Miocene	281
Trilophodon angustidens var. *austro-germanicus* Wegner, 1908, 1913, Oppeln, eastern Germany	Middle Miocene	259
Trilophodon palæindicus Lydekker, 1884, near Kamlial, northern Punjab, India, Kamlial horizon	Middle Miocene	268
Trilophodon pandionis Falconer, 1857, Larkana district, Sind, India, Lower Manchhar	Middle Miocene	267
Trilophodon angustidens minutus Cuvier, 1806, 1824, Saxony	Middle Miocene	252
Trilophodon angustidens Cuvier, 1806, 1817, Simorre, France	Middle Miocene	252
Trilophodon angustidens cuvieri Pomel, 1848, Gers and Sables de l'Orléanais, France	Lower Miocene	250
Trilophodon angustidens gaujaci Lartet, 1851, Lombez, France	Middle(?) Miocene	250
Trilophodon cooperi Osborn, 1932, near Dera Bugti, Baluchistan, Bugti horizon	Lower Miocene	275
Trilophodon pontileviensis Mayet-Fourtau, 1918, Chevilly, Pontlevoy, Sables de l'Orléanais, France	Lower Miocene	283

Trilophodon (Typical, cf. T. angustidens), 'Prod-tuskers' ('Scaptobelodonts') of America

Mandible slender, nearly horizontal or slightly decurved; tusks rounded, rodlike or oval, horizontal or directed upwards

Trilophodon pojoaquensis Frick, 1926, Santa Fé marls, New Mexico	Mio-Pliocene	320
Trilophodon (Genomastodon) osborni Barbour, 1916, Bristow, Boyd County, Nebraska	Lower Pliocene	298
Trilophodon abeli Barbour, 1925, Devil's Gulch, Brown Co., Nebraska	Lower Pliocene	311
Trilophodon (Genomastodon) willistoni Barbour, 1914, Devil's Gulch, Niobrara River, Brown County, Nebraska	Lower Pliocene	293
Trilophodon fricki Peterson, 1928, Brown's Park formation, flanks of Douglas Mountain, Moffat County, Colorado	Middle to Upper Miocene	312

Trilophodon (Tatabelodon), 'Ancient-tuskers'

Mandible massive at symphysis, inferior incisors elongate, rounded or triangular, of massive cross-section

Trilophodon (Tatabelodon) riograndensis Frick, 1933, Santa Fé marls, Battleship Mountain, New Mexico	Mio-Pliocene	324
Trilophodon (Tatabelodon) gregorii Frick, 1933, Ainsworth, Nebraska	Lower Pliocene	324

Trilophodon, 'Oblique-tuskers'

Mandible massive, laterally compressed, more or less strongly decurved; tusks oblique or laterally flattened, directed downwards

Trilophodon dinotherioides Andrews, 1909, northwestern Kansas (?Republican River)	Lower Pliocene	291
Trilophodon ligoniferus Cope and Matthew, 1915, Black Hills, South Dakota (?Republican River level)	Lower(?) Pliocene	298
Trilophodon giganteus Osborn, 1921, Eastview, near Dallas, Gregory County, South Dakota	Lower Pliocene	304

Trilophodon of Eastern Coast of North America

Trilophodon (?Tetralophodon) brazosius Hay, 1923, Brazos River, near San Felipe, Texas	Pliocene(?)	374
Trilophodon simplicidens Osborn, 1923, Bone Valley formation, near Pierce, Polk County, Florida	Lower Pliocene	285
Trilophodon obscurus Leidy, 1869, Greensburgh, Caroline County, Maryland (?Choptank formation)	Miocene(?)	285

Megabelodon, 'Spoonbill Mastodonts'

Megabelodon Barbour, 1914, 1917. Mandible tuskless, round in section, extremely elongate, straight or slightly deflected, slender

Megabelodon lulli Barbour, 1914, 1917, Snake River, Cherry County, Nebraska	Lower(?) Pliocene	294
Megabelodon joraki Frick, 1933, Santa Fé marls, Santa Cruz, New Mexico	Mio-Pliocene	326
Megabelodon cruziensis Frick, 1933, Santa Fé marls, Santa Cruz, New Mexico	Mio-Pliocene	323
Trilophodon phippsi[1] Cook, 1928, Ainsworth, Brown County, Nebraska	Lower Pliocene	315

[1][This species is included with *Megabelodon* because of its tuskless mandible. It was evidently the intention of Professor Osborn to place *Trilophodon phippsi* in the genus *Megabelodon*. See footnote on page 329 above.—Editor.]

Fam.: BUNOMASTODONTIDÆ. Subfam.: GNATHABELODONTINÆ

Genus: *Gnathabelodon*

Mandible tuskless, elongate, spreading broadly at edentulous rostrum, horizontal; no inferior tusks, superior tusks massive, rounded, without enamel, upcurved, elongate. Molars of bunomastodont type, with central conules

GNATHABELODON Barbour and Sternberg, 1935		Page
Gnathabelodon thorpei Barbour and Sternberg, 1935, Ogallah, Trego County, western Kansas	Middle(?) Pliocene	713

Fam.: BUNOMASTODONTIDÆ. Subfam.: AMEBELODONTINÆ

Genera: *Phiomia*, *Amebelodon*

PHIOMIA-AMEBELODON, 'SHOVEL-TUSKERS' OF NORTHERN AFRICA AND NORTH AMERICA

Mandible elongate, slightly upcurved; tusks elongate, broadened, appressed, alveolar portion concave. Conules large

AMEBELODON Barbour, 1927. Inferior incisors with concentric dentinal laminæ		
Amebelodon fricki Barbour, 1927, Freedom, Frontier County, Nebraska	Middle Pliocene	335
Amebelodon (*Trilophodon*) *hicksi* Cook, 1922, Wray, Yuma County, Colorado	Middle Pliocene(?)	307
Amebelodon (*Trilophodon*) *paladentatus* Cook, 1922, Wray, Yuma County, Colorado	Middle Pliocene	309
Amebelodon sinclairi Barbour, 1930, Freedom, Frontier County, Nebraska	Middle Pliocene	337

ANCESTRAL AMEBELODONTINÆ OF NORTH AFRICA

PHIOMIA Andrews and Beadnell, 1902		
Phiomia pygmæus Depéret, 1897, Cartennien de Kabylie, near Isserville, Algeria	Upper(?) Oligocene	246
Phiomia osborni Matsumoto, 1922, Fluvio-marine of the Fayûm, Egypt	Lower Oligocene	64, 244
Phiomia wintoni Andrews, 1905, Fluvio-marine of the Fayûm, Egypt	Lower Oligocene	60, 241
Phiomia wintoni (cf. *serridens*) Andrews ref., Quarry B, Fayûm, Egypt	Lower Oligocene	240, 241
Phiomia serridens Andrews and Beadnell, 1902, Fluvio-marine of the Fayûm, Egypt	Lower Oligocene	55, 239
Phiomia minor Andrews, 1904, Fluvio-marine of the Fayûm, Egypt	Lower Oligocene	58, 239

Fam.: BUNOMASTODONTIDÆ. Subfam.: TETRALOPHODONTINÆ

Genera: *Tetralophodon*, *Morrillia*

Second molars tetralophodont. Mandibles and inferior tusks of medium length (mediongirostral). Inferior tusks flattened, oval; superior tusks enamel banded

TETRALOPHODONTS OF EURASIA

(?)Subgenus LYDEKKERIA Osborn, 1924. Mio-Pliocene. Third molars four to five crested, brachyodont; single to rudimentary double trefoils		
Tetralophodon (*Lydekkeria*) *falconeri* Lydekker, 1877, Potwár district, Punjab, India [Dhok Pathan horizon]	Middle Pliocene	354
Tetralophodon (*Lydekkeria*) *sinensis* Koken, 1885, Yun-nan, China	Mio-Pliocene	355
TETRALOPHODON Falconer, 1847, 1857. Ridge-crests 5½–6, brachyodont; double trefoils		
Tetralophodon punjabiensis Lydekker, 1886, Punjab, Siwaliks, India [Dhok Pathan horizon]	Middle Pliocene	362
Tetralophodon grandincisivus Schlesinger, 1917, Maragha, Persia	Lower(?) Pliocene	360
Tetralophodon bumiajuensis van der Maarel, 1932, Bumiaju, central Java	Pliocene	365
Tetralophodon gigantorostris Kläln, 1922, Bermersheim, Rheinhessen, Germany	Pliocene	282
Tetralophodon longirostris Kaup, 1832, Eppelsheim, Germany	Lower Pliocene	357
Tetralophodon exoletus Hopwood, 1935, Shansi, China, Pontian	Lower Pliocene	704

TETRALOPHODONTS OF NORTH AMERICA

MORRILLIA Osborn, 1924. Ridge-crests 7½–8½, hypsodont; double trefoils, thickly coated with cement		
Morrillia barbouri Osborn, 1921, Cambridge, Furnas County, Nebraska	Middle Pleistocene	377
TETRALOPHODON		
Tetralophodon elegans Hay, 1917, McPherson, Kansas	Middle(?) Pliocene	372
Tetralophodon campester Cope, 1878, Sappa Creek, Rawlins County, Kansas, Republican River horizon	Lower Pliocene	369
Tetralophodon fricki sp. nov., near Clarendon, northern Texas	Lower to Middle Pliocene	375

Fam.: BUNOMASTODONTIDÆ. Subfam.: NOTOROSTRINÆ

Genus: *Cordillerion*

True Notorostrines typified by '*Mastodon*' *andium*. Mandible brevirostral. Superior tusks spiral or horizontal, with broad enamel band. Inferior tusks wanting in adult stages; probably present in juvenile stages. Molars persistently brachyodont with single trefoils, paralleling *Trilophodon*; ridge-crests 4–4½–5½.

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CORDILLERION Osborn, 1926		
Cordillerion andium Cuvier, 1806, 1824, near volcano of Imbaburra, Quito, Ecuador	Pleistocene	549
Cordillerion tarijensis Ameghino, 1902, Valley of Tarija, Bolivia	Pleistocene	550
Cordillerion bolivianus Philippi, 1893, Ulloma, Bolivia	Pleistocene	551
CORDILLERION OF MEXICO		
Cordillerion tropicus Cope, 1884, State of Michoacan, Valley of Mexico	Pliocene or Pleistocene	553
Cordillerion oligobunis Cope, 1893, Tequixquiac, Valley of Mexico	Pliocene or Pleistocene	554
Cordillerion oligobunis antiquissimus Freudenberg, 1922, Valley of Amajaque, Hidalgo, Mexico	Pliocene	555
Cordillerion(?) *oligobunis intermedius* Freudenberg, 1922, Mexico, exact locality not recorded	Pliocene or Pleistocene	557
Cordillerion oligobunis progressus Freudenberg, 1922, Canada de Aculcingo, Mexico	Pliocene or Pleistocene	558
Cordillerion(?) *oligobunis felicis* Freudenberg, 1922, Puebla, Mexico	Pliocene	556
CORDILLERION OF SOUTHWESTERN UNITED STATES		
Cordillerion edensis Osborn, 1922, Mt. Eden Hot Springs, San Bernardino County, California	Upper Pliocene	560
Cordillerion bensonensis Gidley, 1926, near Benson, Cochise County, Arizona, San Pedro formation	Upper Pliocene	565
Cordillerion gratum Hay, 1917, Brazos River, Pittbridge, Burleson County, Texas	Pliocene	559
Cordillerion defloccatus Hay, 1926, Aransas River, San Patricio County, near Sinton, Texas	Pliocene(?)	564
Cordillerion orarius Hay, 1926, Aransas River, San Patricio County, near Sinton, Texas	Pliocene(?)	562

Fam.: BUNOMASTODONTIDÆ. Subfam.: BREVIROSTRINÆ

Genera: *Pentalophodon, Anancus, Synconolophus*

Mandible rapidly abbreviating, in correlation with loss of lower tusks; completely brevirostral in Upper Pliocene time. Grinding teeth, originally short crowned, brachyodont, finally becoming subhypsodont with folded enamel, ptychodont; internal and external cones progressively alternating and proverted; central conules

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PENTALOPHODON OF INDIA		
PENTALOPHODON Falconer, 1857, 1865. Five-crested 'intermediate molars'		
Pentalophodon sivalensis Cautley, 1836, vicinity of Nahun, southeast India, Upper Siwaliks(?)	Upper Pliocene	650
Pentalophodon falconeri Osborn, Upper Siwaliks, Tatrot (?), 1,000 feet above Middle Pliocene Dhok Pathan, India	Upper Pliocene	653
ANANCUS OF EURASIA		
ANANCUS Aymard, 1855, 1859. Superior tusks straight, attaining great length. Four-crested intermediate molars		
Anancus falconeri Osborn, 1926, Red or Norwich Crag of Suffolk, England	Uppermost Pliocene	636
Anancus arvernensis Croiz. & Job., 1828, Perrier, Auvergne, France, Villafranchian-Astian	Upper Pliocene	632
Anancus arvernensis brevirostris Gervais and de Serres, 1846, Montpellier, Hérault, France	Upper Pliocene	634
Anancus perimensis Falconer and Cautley, 1847, Perim Island, India [=Dhok Pathan]	Middle Pliocene	643
Anancus minutoarvernensis Klähn, 1922, Herbolzheim, Baden, Germany	Pliocene	283
Anancus gigantarvernensis Klähn, 1922, Herbolzheim, Baden, Germany	Pliocene	283
Anancus intermedius Eichwald, 1831, Volhynia, Russia	Pliocene	639
Anancus arvernensis progressor Khomenko, 1912, southern Bessarabia, Russia	Pliocene	639
Anancus properimensis sp. nov., near Chinji Bungalow, Lower Chinji, 800 feet above base of Lower Siwaliks	Mio-Pliocene	647
Anancus sinensis Hopwood, 1935, Shansi, China	Pliocene(?)	721
SYNCONOLOPHUS OF INDIA		
SYNCONOLOPHUS Osborn, 1929. Warped, compacted conelets and conules, no trefoils		
Synconolophus dhokpathanensis Osborn, 1929, Dhok Pathan, level of *Hipparion punjabiense* (?) ref. quarry, 500 feet below top of Middle Siwaliks, India	Middle Pliocene	661
Synconolophus hasnoti Pilgrim, 1913, near Bhimbar, India [=Dhok Pathan horizon]	Middle Pliocene	659
Synconolophus corrugatus Pilgrim, 1913, Hasnot, India [=Dhok Pathan horizon]	Middle Pliocene	658
Synconolophus propathanensis Osborn, 1929, near Dhok Pathan, India, *Hipparion* quarry level, 500 feet below top of Middle Siwaliks (Dhok Pathan horizon)	Middle Pliocene	665
Synconolophus ptychodus Osborn, 1929, near Chinji Bungalow, India, Lower Chinji, 800 feet above base of Lower Siwaliks	Mio-Pliocene	657

Fam. nov.: HUMBOLDTIDÆ. Subfam.: HUMBOLDTINÆ

Genera: *Cuvieronius, Eubelodon, Stegomastodon*

Superior tusks without enamel. Molars with single, double, or quadruple trefoils; ridge-crests $4_{.1}$ to $7_{.1}$; inferior ridge-crests proverted; superior ridge-crests transverse, centroverted, or retroverted. Central conules rudimentary or wanting.

All species below arranged in ascending order of the evolution of the grinding teeth. Geologic levels of South American species uncertain.

NORTH AMERICAN SPECIES

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EUBELODON Barbour, 1914. Grinders broad, double trefoils		
Eubelodon morrilli Barbour, 1914, Devil's Gulch B, Brown County, Nebraska	Middle(?) Pliocene	602

SOUTH AMERICAN SPECIES

CUVIERONIUS Osborn, 1923. Grinders broad, double trefoils; single trefoils in primitive species		
Cuvieronius humboldtii Cuvier, 1806 (in Desmarest, 1818), near Concepcion, Chile [Ecuador?]	Pleistocene	576
Cuvieronius platensis Ameghino, 1888, San Nicolás de los Arroyos, Province of Buenos Aires, Argentina, Lower Pampean formation	Pleistocene	579
Cuvieronius superbus Ameghino, 1888, Pergamino, Province of Buenos Aires, Argentina, probably Superior Pampean	Pleistocene	580
Cuvieronius bonaerensis Moreno, 1888, Arrecifes, Province of Buenos Aires, Argentina, Lower Pampean	Pleistocene	579
Cuvieronius rectus Ameghino, 1889, Ensenada, near La Plata, Argentina		580
Cuvieronius maderianus Ameghino, 1891, Puerto Madero in Buenos Aires, Argentina		581
Cuvieronius chilensis Philippi, 1893, near Lake Tagua-Tagua, Chile		581
Cuvieronius pirayuiensis Gez, 1915, Corrientes, Argentina		582
Cuvieronius brasiliensis Lund (in Lesson, 1842), valley of the Velhas River, Province of Minas Geraes, Brazil, limestone cave		578
Cuvieronius postremus Spillmann, 1928–1931, Quebrada of Cachihuayco, near Alangasi, Province of Pichincha, Ecuador	Superior Pleistocene	585
Cuvieronius ayoræ Spillmann, 1928–1931, Quebrada of Chalang, near Punin, Province of Chimborazo, Ecuador	Pleistocene	583

STEGOMASTODON OF NORTH AMERICA

STEGOMASTODON Pohlig, 1912. Grinders with quadruple to multiple trefoils completely blocking the valleys; inferior ridge-crests proverted; cones ptychodont, labyrinthodont, subhypsodont		
Stegomastodon priestleyi Hay and Cook, 1930, near Frederick, Tillman County, Oklahoma		684
Stegomastodon primitivus sp. nov., near Ainsworth, Nebraska	Lower Pleistocene	726
Stegomastodon mirificus Leidy, 1858, "Loup Fork of Platte River," Nebraska [probably near Seneca, Thomas County, Nebraska (*fide* Hay, 1924, p. 100)]	Upper Pliocene(?)[1]	669
Stegomastodon successor Cope, 1892, Blanco formation, Texas	Upper Pliocene	671
Stegomastodon texanus Osborn, 1924, Llano Estacado, Texas, Blanco formation	Upper Pliocene	673
Stegomastodon arizonæ Gidley, 1924, 1926, Curtis Flats, Cochise County, Arizona, San Pedro beds	Uppermost Pliocene	678
Stegomastodon aftoniæ Osborn, 1924, near Akron, Plymouth County, Iowa	Lower Pleistocene[2]	682

INCERTÆ SEDIS

Stegomastodon chapmani Hays, 1834, 1843, unrecorded locality in United States		669

Fam. nov.: SERRIDENTIDÆ. Subfam.: SERRIDENTINÆ

Genera: *Serridentinus, Ocalientinus, Serbelodon, Trobelodon*

Serrate-toothed mastodonts. Superior and inferior molars universally characterized by more or less perfectly developed and serrated crests springing from the ectoconelets of the inferior molars, from the entoconelets of the superior molars. Generic divergence chiefly in inferior incisors—horizontal oval in *Serridentinus*, oval, greatly enlarged in *Serbelodon*, flattened into a pair of broad shovels in *Platybelodon*, abbreviated and rounded in *Torynobelodon*, and entirely wanting, with brevirostral mandible, in *Notomastodon*.

SERRIDENTINES OF EURASIA

SERRIDENTINUS Osborn, 1923		
Serridentinus hasnotensis Osborn, 1929, near Hasnot, India, Upper Middle Siwaliks (Dhok Pathan horizon)	Middle Pliocene	452
Serridentinus metachinjiensis Osborn, 1929, near Chinji Bungalow, India, Lower Chinji, 800 feet above base of Lower Siwaliks (cf. *S. productus*)	Mio-Pliocene	456

[1][Lower to Middle Pleistocene (see footnote on p. 669).—Editor.]

[2][Lower to Middle Pleistocene (see footnote on p. 671).—Editor.]

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Serridentinus prochinjiensis Osborn, 1929, near Chinji Bungalow, India, Lower Chinji, 600 feet above base of Lower Siwaliks, small, primitive (cf. *S. productus*)	Mio-Pliocene	457
Serridentinus chinjiensis Osborn, 1929, near Chinji Bungalow, India, Lower Chinji, 700 feet above base of Lower Siwaliks, sharp crested (cf. *S. serridens*)	Mio-Pliocene	456
Serridentinus browni Osborn, 1926, near Chinji Bungalow, India, Lower Chinji, 800 feet above base of Lower Siwaliks, blunt crested (cf. *S. productus*)	Mio-Pliocene	452
Serridentinus gobiensis Osborn and Granger, 1932, near Iren Dabasu, Inner Mongolia, Tung Gur	Upper Miocene	398
Serridentinus mongoliensis Osborn, 1924, Loh formation, Mongolia, blunt crested	Lower to Middle Miocene	396

Serridentines of China and Japan

Serridentinus lydekkeri Schlosser, 1903 (1906), Red Clays, North China	Lower Pliocene(?)	457
Serridentinus wimani Hopwood, 1935, Kansu, China	Miocene(?)	732
Serridentinus annectens Matsumoto, 1924, Province of Mino, Japan, Hiramaki formation, probably Burdigalian	Lower Miocene	457

Serridentines of Europe

Serridentinus subtapiroideus Schlesinger, 1917, Wies, near Eibiswald (Styria), Austria (Lower Helvetian)	Lower Middle Miocene	394
Serridentinus filholi Frick, 1926, 1933, Gers, France	Lower Miocene	473

Serridentines of North and Central America

Sharp-crested Forms

Serridentinus serridens cimarronis Cope, 1893, east of Llano Estacado, Texas, Clarendon formation, *Procamelus-Hipparion* zone	Lower Pliocene	429
Serridentinus serridens Cope, 1884, Clarendon formation, Texas	Lower Pliocene	423
Serridentinus anguirivalis Osborn, 1926, Snake Creek B, Sioux County, western Nebraska	Lower Pliocene	425
Serridentinus brewsterensis Osborn, 1926, Brewster, Polk County, Florida, Bone Valley formation	Lower Pliocene	430

Blunt-crested Forms

Serridentinus guatemalensis Osborn, 1926, Chinautla, Guatemala	Upper Pliocene	432
Serridentinus progressus Osborn, 1923, Driftwood Creek, Hitchcock County, Nebraska	Pliocene(?)	401
Serridentinus (*Ocalientinus*?) *nebrascensis* Osborn, 1924, Snake Creek B, Sioux County, Nebraska	Lower Pliocene	473
Serridentinus productus Cope, 1875, Santa Fé marls, New Mexico (type)	Upper Miocene	404
Clarendon formation, Texas (ref.)	Lower Pliocene	404
Serridentinus proavus Cope, 1873, Pawnee Buttes, Pawnee Creek B, Weld County, Colorado	Upper Miocene	403

Incertæ sedis

Serridentinus barstonis Frick, 1933, Mohave Desert, California, Barstow beds	Mio-Pliocene	447

Ocalientinus of Mongolia

Ocalientinus Frick, 1933. Trefoils florescent; mandible longirostral, deeply grooved above; inferior tusks of 'prod-tusk' type

Ocalientinus florescens Osborn, 1929, Kholobolchi Nor region, Khunuk formation, Mongolia	Pliocene	397

Ocalientinus of North America

Ocalientinus obliquidens Osborn, 1926, Charleston, South Carolina, phosphate beds	Upper Pliocene, redeposited in Lower Pleistocene	419
Ocalientinus bifoliatus Osborn, 1929, Brewster, Polk County, Florida, Alachua clays	Lower Pliocene	415
Ocalientinus floridanus Leidy, 1886, near Williston, Levy County, Florida, Alachua clays	Lower Pliocene	416
Ocalientinus floridanus leidii Frick, 1926, near Williston, Levy County, Florida, Alachua clays	Lower Pliocene	419
Ocalientinus republicanus Osborn, 1926, Republican River formation, northwestern Kansas	Lower Pliocene	414
Ocalientinus ojocaliensis Frick, 1933, Ojo Caliente, New Mexico, Santa Fé marls (upper)	Mio-Pliocene	435
Ocalientinus emmonsi Hay, 1930, marl beds of Halifax County, North Carolina	Miocene	733

Serbelodon of North America

Serbelodon Frick, 1933, 'sub-shovel-tuskers.' Mandible massive, inferior tusks concavo-convex, increasingly massive, without dentinal rod-cones

Serbelodon burnhami Osborn, 1933, near Ricardo, San Bernardino County, California	Upper Pliocene	444
Serbelodon barbourensis Frick, 1933, near Ainsworth, Nebraska, Christmas quarry	Lower Pliocene	443

Phyletic relationship uncertain

Serbelodon(?) *præcursor* Cope, 1892, 1893, Mt. Blanco, Llano Estacado, Blanco formation, Texas, sharp crested, trefoils simple, cement in valleys	Upper Pliocene	431

TROBELODON OF NORTH AMERICA

TROBELODON Frick, 1933, 'sub-shovel-tuskers' — Page

Trobelodon taoensis Frick, 1933, Santa Cruz, New Mexico, Santa Fé marls (rare) ..... Mio-Pliocene — 446

Fam. nov.: SERRIDENTIDÆ. Subfam.: PLATYBELODONTINÆ

Genera: *Platybelodon*, *Torynobelodon*

PLATYBELODONTS OF ASIA AND NORTH AMERICA

PLATYBELODON Borissiak, 1928, 1929, typical 'flat-tuskers.' Incisors solid with closely compacted rod-cones

Platybelodon danovi Borissiak, 1928, Kuban region, North Caucasus, Chokrak beds ..... Upper Miocene — 461

Platybelodon grangeri Osborn, 1929, Tairum Nor basin, Mongolia, Tung Gur horizon ..... Upper Miocene — 463

TORYNOBELODON Barbour, 1929, 'dredge-tuskers'

Torynobelodon loomisi Barbour, 1929, Sand Canyon, east of Indian Hill, vicinity of Republican City, Harlan County, Nebraska ..... Middle Pliocene — 338

Torynobelodon barnumbrowni Barbour, 1931, Pliocene gravels on Snake River, Cherry County, Nebraska ..... Pliocene — 470

Fam. nov.: SERRIDENTIDÆ. Subfam. nov.: NOTIOMASTODONTINÆ

Genus: *Notiomastodon*

SERRIDENTINES OF SOUTH AMERICA

NOTIOMASTODON Cabrera, 1929

Notiomastodon ornatus Cabrera, 1929, Monte Hermoso, Province of Buenos Aires, Argentina ..... Lower Pleistocene(?) — 590, 731

Notiomastodon argentinus Ameghino, 1888, Valley of Tarija, Argentina, exact locality unrecorded ..... Pliocene — 550

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[1]Incorrectly given as 9908.
[2]Incorrectly given as 10455.

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[1]Incorrectly listed as *Synconolophus dhokpathanensis*.

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[1] An incorrect determination and number.

[2] Erroneously referred to *Trilophodon osborni*.

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[1]Erroneously referred to *Trilophodon osborni.*
[2]Erroneously referred to *Trilophodon gregorii.*
[3]Erroneously written 22722.
[4]Erroneously written 22725.

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University of Leipsic, Palæontological Museum

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Paläontologisches Institut der Universität, Vienna

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Yale University, Peabody Museum of Natural History

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Zoological Society, London

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Zurich Collection, Elgg, Switzerland

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BIBLIOGRAPHY OF THE PROBOSCIDEA, 1602-1935

The present Bibliography includes titles ranging in date from 1602 to 1935. Such omissions as may be discovered will be placed in a supplementary bibliography at the close of the second volume, referring to all the essential literature of both Volumes I and II.

The total Bibliography of the Proboscidea is too vast to be included here; supplementary titles must be sought in special Memoirs. For the Proboscidea of Eurasia and Africa, see especially Memoirs of:

Cuvier (1806–1836)
Fischer de Waldheim (1834)
Von Meyer and Göppert (1848)
Falconer (1845–1868)
Warren (1852–1855, including North America)
Brandt (1869)
Gaudry (1862.1)
Vacek (1877.1)
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Weinsheimer (1883.1)
Depéret (1885–1908; especially 1923.1—Pliocene elephants)
Howorth (1887.1)
Capellini (1888.1, 1893.1, 1907–1908)
Pohlig (1889–1892)
Weithofer (1889–1893)
Trouessart (1897–1905)
Sherborn (1902–1933)
Palmer (1904.1)
Mayet (1908.1)
Mayet and Roman (1923.1)
Schlesinger (1911–1922, especially 1917.1, 1922.1)
Soergel (1912–1929—Plio-Pleistocene Proboscidea)
Dietrich (1912–1924)
Zuffardi (1913.1)
Freudenberg (1922.1)
Matsumoto (1918.1, 1926.1, 1929.1)
Cabrera (1929.1—South America)
De Lorenzo and D'Erasmo (1927–1931)

For the Proboscidea of America up to the year 1869, see Leidy (1869.1), after the year 1869, see Hay (1902.1, 1929.1); for the geographic distribution of *Mastodon americanus* of the Pleistocene, see Hay (1923.1, 1924.1, 1927.1), also figure 123b of the present Memoir.

The annotations in the present Bibliography epitomize the principal points in (a) nomenclature, (b) geologic or time correlation, (c) geographic distribution. In certain instances the present author has added his own comments, and where there might be danger of ambiguity, these comments have been inserted in square brackets.

The reader's attention is called to the numbers used in connection with the titles by the present author. These numbers correspond to those assigned in the Osborn Bibliography of 1930 appearing in his "Fifty-Two Years of Research, Observation and Publication" and in the Supplements issued since that time.

Anonymous

1827.1 Analytical Notices of Books . . . Histoire Naturelle des Mammifères, avec des Figures originales, dessinées d'après des Animaux vivans; etc. Par MM. Geoffroy Saint-Hilaire et F. Cuvier. Zool. Journ. London, III, pp. 140–143.
New genus: *Lozodonta*.

1832.1 Ueber die neuliche Entdeckung eines fossiles Elephanten-Skelett. Isis, [XXV], Heft X, pp. 1111–1114. Signed "Ein Naturforscher in St. Petersburg."
E. affinis, Heft X, 1832, p. 1112, attributed to "Herr B" [Herr Brandt (?)] Review in Neues Jahrb. Min., 1833, pp. 610, 611.

1832.2 Unsigned review of Eichwald's Naturhistor. Skizze von Lithauen, Volhynien und Podolien. Wilna, 1830, pp. 238–253. Neues Jahrb. Min., pp. 354–356.

1906.1 The Skull of an Elephant with but One Tusk. The Haslemere Museum Gazette, I, No. 1, May, p. 13, Pl. 1. [Probably by Ernest William Swanton, Assistant Editor and Curator of the Museum.]
Elephas indicus from Ceylon.

1909.1 The Imperial Gazetteer of India. New Edition, XXVI. 8vo, Oxford, Clarendon Press.
Includes 64 maps and General Index.

1928.1 Tetrabelodon Nov. Spec. Ayora-Spillm. El Ecuador Comercial, Año VI, March, No. 57. Quito, Ecuador.

1928.1 El Mastodonte de Alangasi. El Ecuador Comercial, Año VI, March, No. 57, pp. 74, 75. Quito, Ecuador.

1934.1 Discovery of Another Mammoth Skull in New York State. Ward's Nat. Sci. Bull., No. 1, October, p. 4, fig. Rochester.

1935.1 Recent Acquisitions at the British Museum (Natural History). Nature, CXXXVI, No. 3431, Aug. 3, p. 176.
Skull and tusks of a young specimen of the forest elephant, from the Gola Forest, Sierra Leone, important as accompanied by two complete tusks "in every way similar to the tusks hitherto accepted as belonging to the so-called 'dwarf' elephant."

Abel, Othenio

1907.1 Über die Bedeutung der neuen Fossilfunde im Alttertiär Ägyptens für die Geschichte der Säugetiere. Verh. k. k. zool.-bot. Ges. Wien, LVII, pp. 78–80.

1911.1 Die Bedeutung der fossilen Wirbeltiere für die Abstammungslehre. Die Abstammungslehre (Abel, Brauer, Dacqué *et al.*). 8vo, Jena, pp. 198–250, text figs. 1–33.
Phylogeny and environment.

1912.1 Grundzüge der Palaeobiologie der Wirbeltiere. 8vo, Stuttgart, pp. xv+708, 470 text figs.
Phylogeny and environment.

1914.1 Die vorzeitlichen Säugetiere. 8vo, Jena, pp.v+309, 250 text figs.
Phylogeny.

1914.2 Neue Rekonstruktion des Mammut nach den Zeichnungen des Eiszeitmenschen. Verh. k. k. zool.-bot. Ges. Wien, LXIV, pp. 21–30, 3 text figs.

1919.1 Die Rekonstruktion von Mastodon angustidens Cuv. Naturw. Wochenschr., N. F., XVIII, pp. 217–224, 3 text figs.

1922.1 Lebensbilder aus der Tierwelt der Vorzeit. 8vo, Jena, pp. vii+643, frontispiece and 507 text figs.
Dinotherium, fig. 82.

1925.1 Geschichte und Methode der Rekonstruktion vorzeitlicher Wirbeltiere. 8vo, Jena, 327 pp., 255 text figs.

1928.1 Plastische Rekonstruktion des Lebensbildes von Bunolophodon angustidens. Palaeobiologica, I, pp. 481–486, Pls. xxxvii, xxxviii.

Abich, Otto Wilhelm Hermann von

1859.1 Ueber das Steinsalz und seine geologische Stellung im russischen Armenien. Mém. Acad. Imp. Sci. St. Pétersb., (6), IX, Math. et Phys., VII, pp. 59–150, Pls. i–x.

Absolon, Karel

1929.1 An Amazing Palæolithic "Pompeii" in Moravia.—I, II. Revelations concerning the Mammoth-Hunters of Central Europe. The Illustrated London News, CLXXV, No. 4727, Nov. 23, pp. 881, 890–894; No. 4728, Nov. 30, pp. 934–938.

Acconci, Luigi

1880.1 Sopra una Caverna Fossilifera Scoperta a Cucigliana (Monti Pisani). Atti Soc. Toscana Sci. Nat., V, Fasc. I, pp. 109–166, Pls. i–iv.
New species: *Elephas (Eurelephas) antiquus* var. *nana*.

Adams, Andrew Leith

1868.1 Has the Asiatic Elephant been found in a Fossil State? . . . With Some Additional Remarks; by G. Busk, Esq., F.R.S., F.G.S. Quart. Journ. Geol. Soc. London, XXIV, Pt. I of Proc. Geol. Soc., pp. 496–499, text fig.

1870.1 Notes of a Naturalist in the Nile Valley and Malta. 8vo, Edinburgh, pp. xvi+295, 11 pls. and other illustrations.
New species: *Elephas mnaidræ*, p. 224.

1874.1 On the Dentition and Osteology of the Maltese fossil Elephants, being a Description of Remains discovered by the Author in Malta between the Years 1860 and 1866. Trans. Zool. Soc. London, IX, Pt. I, November, pp. 1–124, Pls. i–xxii, text figs. 1–9.
Elephas melitensis and *E. mnaidriensis*. Name *mnaidræ* (1870) changed to *mnaidriensis*, p. 116.

1877-1881 Monograph on the British Fossil Elephants. 4to, London, 265 pp., 28 pls.

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1808.1 Some Account of a Journey to the Frozen Sea, and of the Discovery of the Remains of a Mammoth. Phil. Mag. (Tilloch), XXIX, October-December, 1807, and January, 1808, pp. 141–153.

Agassiz, Jean Louis Rodolphe

1850.1 On the Fossil Remains of an Elephant found in Vermont. Proc. Amer. Assoc. Adv. Sci., 2d Meeting, pp. 100, 101.
Slope of Mt. Holly, Vermont.

1853-1856 See Bronn, Heinrich Georg.
Deinotherium, p. 805.

1862.1 Mastodon tooth in Amador Co., California. Amer. Journ. Sci., (2), XXXIV, p. 135.
Editorial note supposed to have been written by Agassiz (*fide* Hay, 1902).

Aichel, Otto

1918.1 Kausale Studie zum ontogenetischen und phylogenetischen Geschehen am Kiefer. Abh. kgl. preuss. Akad. Wiss., Phys.-math. Kl., Nr. 3, August, pp. 1–109, Pls. i–v, text figs. 1–21.

Aichhorn, Sigmund Johann Nepomuk

1857.1 Der Aufmerksame. (*Fide* Weinsheimer, 1883.1, p. 215; original not available.) See "Fossile Knochen in Steyermark," Neues Jahrb. Min., 1857, p. 375.
Mastodon and *Dinotherium*.

Airaghi, Carlo

1917.1 Sui Molari d'Elefante delle Alluvioni Lombarde con Osservazioni sulla Filogenia e Scomparsa di Alcuni Proboscidati. Mem. Soc. ital. Sci. Nat., VIII, Fasc. III, pp. 193–242, Tav. xiii–xv. Milano.

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Dinotherium gigantissimum, D. giganteum, D. medium, D. bavaricum, D. Cuvieri, D. indicum, D. pentapotamiæ, D. sindiense.

Ameghino, Florentino

1878.1 Catalogue Spécial de la Section Anthropologique et Paléontologique de la République Argentine. Expos. Univ. de 1878. Groupe second—Classe huitième, 80 pp. 8vo, Paris.
Proboscidea, pp. 38 and 57.

1888.1 Rápidas diagnosis de algunos Mamíferos Fósiles Nuevos de la República Argentina. 8vo, Buenos Aires, Feb. 15, 17 pp.
New species: *Mastodon argentinus, M. platensis, M. superbus.*

1889.1 Contribucion al Conocimiento de los Mamiferos Fósiles de la República Argentina. Actas Acad. Nac. Cien. Córdoba, VI, pp. xxxii+1027, text figs. Atlas, 98 pls.
New species: *Mastodon rectus*, p. 643. Type figures of *Mastodon platensis*, p. 641, *M. rectus*, p. 643, *M. argentinus*, p. 644, *M. superbus*, p. 647.

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1902.1 Línea filogenética de los Proboscídeos. An. Mus. Nac. Buenos Aires, VIII (Ser. 3ª, I), pp. 19–43, text figs. 1–38.

1902.2 Cuadro Sinóptico de las Formaciones sedimentarias, Terciarias y Cretáceas de la Argentina en relación con el desarrollo y descendencia de los Mamíferos. An. Mus. Nac. Buenos Aires, VIII (Ser. 3ª, I), pp. 1–12.
New species: *Mastodon tarijensis* (name only).

Ami, Henry Marc

1898.1 The Mastodon in Western Ontario. Science, N. S., VII, p. 80.

Anderson, Netta C., and Johan August Udden

1905.1 A Preliminary List of Fossil Mastodon and Mammoth Remains in Illinois and Iowa. By Netta C. Anderson. Augustana Library Publ., No. 5, Rock Island, Ill., pp. 9–43, 2 maps. On the Proboscidean Fossils of the Pleistocene Deposits in Illinois and Iowa. By Johan August Udden, *ibid.*, pp. 45–57.
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Anderson, Robert Van Vleck

1927.1 Tertiary Stratigraphy and Orogeny of the Northern Punjab. Bull. Geol. Soc. Amer., XXXVIII, Dec. 30, pp. 665–720, map.

Andreae, Achilles

1904.1 Dritter Beitrag zur Binnenconchylienfauna des Miocäns von Oppeln in Schlesien. Mitt. Roemer-Mus. Hildesheim, No. 20, August, pp. 1–22, text figs. 1–15.
Mastodon angustidens listed, p. 19.

Andrews, Charles William

1901.1 Fossil Vertebrates from Egypt. Zoologist, (4), V, Aug. 15, pp. 318, 319.
New genus: *Palæomastodon* (name only). New species: *Palæomastodon beadnelli* (name only).

1901.2 Tageblatt des V Internationalen Zoologen-Congresses. Berlin, No. 6, Aug. 16, p. 4. (Published Volume, Verhandlungen, 1902, p. 528.)
New genus: *Mœritherium*. New species: *Mœritherium lyonsi*. Further mention of *Palæomastodon beadnelli*.

1901.3 Preliminary Note on Some Recently Discovered Extinct Vertebrates from Egypt. (Part I). Geol. Mag., Dec. IV, N.S., VIII, September, pp. 400–409, 4 text figs.
Palæomastodon beadnelli and *Mœritherium lyonsi*, description and figure.

1902.1 Preliminary Note on Some Recently Discovered Extinct Vertebrates from Egypt. (Part III). Geol. Mag., Dec. IV, N.S., IX, July, pp. 291–295.
New species: *Mœritherium gracile.*

1903.1 On the Evolution of the Proboscidea. Phil. Trans. Roy. Soc. London, CXCVI, B, pp. 99–118, text figs. 1–15.
Proboscidea: *Mœritherium* and *Palæomastodon*. Possible inclusion of *Barytherium* and *Arsinoitherium* in the Proboscidea. Demonstration of an Ethiopian center of distribution of the Proboscidea.

1903.2 Note on a Tooth of Elephas namadicus. Reprint from Fasciculi Malayenses. Zoology—I, p. 307.
Molar found on Bukit Besar, Nawngchik.

1904.1 Further Notes on the Mammals of the Eocene of Egypt. Geol. Mag., Dec. V, N.S., I, March, pp. 109–115, 2 text figs.
New species: *Mœritherium trigodon* and *Palæomastodon minor.*

1905.1 Note on the Species of Palæomastodon. Geol. Mag., Dec. V, N. S., II, December, pp. 562, 563.
New species: *Palæomastodon parvus* and *Palæomastodon wintoni*. *Palæomastodon minus* cited in error for *P. minor*, p. 562.

1906.1 A Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt. 4to, London, pp. xxxvii+324, 26 pls., 98 text figs.
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1907.1 Note on Some Vertebrate Remains Collected in the Fayûm, Egypt, in 1906. Geol. Mag., Dec. V, N. S., IV, March, pp. 97–100, text figs. 1, 2.

1908.1 On the Skull, Mandible, and Milk Dentition of Palæomastodon, with some Remarks on the Tooth Change in the Proboscidea in General. Phil. Trans. Roy. Soc. London, CXCIX, B, pp. 393–407, Pls. xxxi, xxxii.

1908.2 A Guide to the Elephants (Recent and Fossil) . . . British Museum (Natural History). 8vo, London, 46 pp. 31 text figs.

1909.1 Note on the Mandible of a New Species of Tetrabelodon from the Loup Fork Beds of Kansas. Geol. Mag., Dec. V, N.S., VI, August, pp. 347–349, text figs. A, B, C.
New species: *Tetrabelodon dinotherioides.*

Andrews, Charles William—Continued

1909.2 The Systematic Position of Mœritherium. Nature, LXXXI, p. 305.

1911.1 On a New Species of Dinotherium from British East Africa. Abstract, Proc. Zool. Soc. London, No. 97, May, p. 35.

New species: *Dinotherium hobleyi*.

1911.2 On a New Species of Dinotherium (Dinotherium hobleyi. . .) from British East Africa. Proc. Zool. Soc. London, December, pp. 943–945, Pl. xlviii.

1912.1 Note on the Molar Tooth of an Elephant from the Bed of the Nile, Near Khartum. Geol. Mag., Dec. V, N. S., IX, March, pp. 110–113, text figs. A, B.

Elephas meridionalis (?) [=*Deinotherium* sp.], together with hippopotamus, giraffe, antelope, and a siluroid fish.

1917.1 [Discovery of large specimen of Elephas antiquus near Chatham, England.] Proc. Geol. Soc. London, LXXII, pp. i, ii, Session, Nov. 3, 1915.

"First British example of this species in which the skeleton has been found directly associated with the teeth." [For full description see Andrews and Cooper, 1928.1.]

1921.1 Note on the Skull of Dinotherium giganteum in the British Museum. Proc. Zool. Soc. London, September, pp. 525–534, text figs. 1–4.

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1902.1 A Preliminary Note on Some New Mammals from the Upper Eocene of Egypt. Surv. Dept., Pub. Works Ministry, Cairo, pp. 1–9, text figs. 1–4.

New genus: *Phiomia*. New species: *Phiomia serridens*.

Andrews, Charles William, and Clive Forster Cooper

1928.1 On a Specimen of Elephas antiquus from Upnor. With further notes on the Teeth and Skeleton by Clive Forster Cooper. 4to, British Museum, London, issued Feb. 25, pp. viii+25, frontispiece, 8 pls., 5 text figs.

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Andrusov, Nikolai Ivanovich

1902.1 Die südrussischen Neogenablagerungen. Verh. russisch.-kaiserl. Min. Ges. St. Petersb., (2), XXXIX, pp. 337–495, Tab. ix.

Anthony, Harold Elmer, and Henry Fairfield Osborn

1922.1 See Osborn, Henry Fairfield, 1922.553.

1922.2 See Osborn, Henry Fairfield, 1922.568.

Anthony, Raoul Louis Ferdinand, and G. Pontier

1929.1 Sur la présence de quatre incisives supérieures chez le Mastodon (Tetrabelodon) turicensis Schinz. Compt. Rend. Acad. Sci., CLXXXIX, No. 23, Dec. 2, pp. 1006–1008, text figs. 1, 2. Paris.

Anthony, Raoul Louis Ferdinand, and M. Prouteaux

1929.1 Un Crâne d'Éléphant d'Afrique (Loxodonta africana Blum.) à quatre incisives supérieures. Arch. Mus. hist. nat., (6), IV, pp. 15–31, Pl. i, text figs. 1–4. Paris.

Aradas, Andrea

1870.1 Sopra un Molare Elefantino Fossile Riferibile a Specie Distinta dalle Conosciute. Atti Accad. Gioenia sci. nat. Catania, (3), IV, pp. 231–235, Tav. (figs. 1, 2).

New species: *Elephas Cornaliae*, p. 235.

Artaud, Soulange

1803.1 Manuel d'Histoire Naturelle, traduit de l'Allemand, de J. Fr. Blumenbach . . , I, II, with figures. (See Blumenbach.)

Elephas asiaticus, E. Africanus, E. primigenius, mammout Ohioticum.

Athanasiu, Sava C.

1908.1 Contributiuni la studiul Faunei Tertiare de Mamifere din România. Anuar. Inst. Geol. României, I, pp. 129–214, Tab. i–xii, with German résumé. Bucharest.

Dinotherium gigantissimum, Mastodon borsoni especially.

1909.1 Contributiuni la studiul Faunei Tertiare de Mamifere din România. Anuar. Inst. Geol. României, II, pp. 379–435, Tab. i–x, with German résumé. Bucharest.

Mastodon arvernensis especially.

1915.1 Resturile de Mamifere Pliocene Superiora e dela Tulucești In Districtul Covurlui. Anuar. Inst. Geol. României, VI, pp. 408–415, Tab. xiii, fig. 5, Tab. xvii, figs. 1–4. Bucharest.

Mastodon arvernensis, M. borsoni; Elephas cf. *meridionalis* [made by Stefănescu (1924) type of *Elephas antiquus rumanus*].

Avalo y Figueroa, Diego de

1602.1 Miscelánea austral. Coloquio, XXXIII, p. 147. Lima. (*Fide* Ameghino, 1889, p. 634; original not available.)

Fossil bones found in Tarija.

Aymard, Auguste

1847.1 Résumé d'une lettre de M. Aymard sur les ossements humains fossiles des environs de Puy, et sur de nouvelles espèces de Mastodontes. Bull. Soc. géol. France, (2), IV, pp. 412–416.

New species: *Mastodon tellaeus, M. Vialetii*. First description of *Anancus macroplus* but without assigning name.

1859.1 Communication par M. Aymard sur le gisement fossilifère de Coupet; nouvelle liste de fossiles. Ann. Soc. Agric. Puy, XX, for 1855–1856 (Procès-Verbaux, Janvier), pp. 30–40.

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Bach, Franz

1908.1 Das Alter des "Belvedereschotters." Centralb. Min. Geol. Pal., No. 13, July 1, pp. 386–390. Stuttgart.

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Proboscidea, pp. 81–89.

1910.1 Mastodon reste aus der Steiermark. Beitr. Pal. Geol. Österr.-Ung., XXIII, pp. 63–123, Taf. vii–x. Wien.

Mastodon angustidens, M. longirostris, M. arvernensis, M. tapiroides, M. borsoni, and transitional forms.

Bachmann, Isidor

1875.1 Beschreibung eines Unterkiefers von Dinotherium bavaricum Hermann von Meyer aus dem Berner Jura. Abh. schweiz. pal. Ges., II, pp. 1–19, Taf.

Baldassari, Giuseppe

1767.1 Descrizione di una mascella fossile straordinaria trovata nel territorio senese. Atti Accad. Sci. Fis. Siena, III, pp. 243–254, Tav. v–viii.

Barbiani, A.

1907.1 Cenni sul Mastodonte di Petroio (prov. di Siena) e sugli strati Levantini in cui si rinvenne. Riv. ital. Pal., XIII, pp. 91–99, Tav. i. Perugia.

Mastodon arvernensis.

Barbour, Erwin Hinckley

1890.1 Remains of the Primitive Elephant found in Grinnell, Io. Science, XVI, p. 263.

Elephas primigenius.

1913.1 A Tooth of the Columbian Mammoth. Neb. Geol. Surv., IV, Pt. 5, pp. 58–65, Pls. i, ii, text fig.

Elephas columbi tooth from near Dannebrog, Howard Co., Nebraska.

1914.1 Mammalian Fossils from Devil's Gulch. Univ. Studies, Univ. Neb., XIV, No. 2, April, pp. 185–202, Pls. i–xiv.

New genus: *Eubelodon*. New species: *Tetrabelodon willistoni* and *Eubelodon morrilli*.

1914.2 Mammalian Fossils from Devil's Gulch. Neb. Geol. Surv., IV, Pt. 11, pp. 177–190, Pls. i–xiii.

Reprint from University Studies.

1914.3 A New Longirostral Mastodon from Cherry County, Nebraska. Neb. Geol. Surv., IV, Pt. 14, pp. 213–222, Nov. 25, Pls. i–vi, text figs. 1–6.

New subgenus: *Megabelodon*. New species: *Tetrabelodon* (subgenus *Megabelodon*) *lulli*.

1915.1 The Round Ligament of Nebraska Proboscideans. Neb. Geol. Surv., IV, Pt. 18, Jan. 25, pp. 241–246, text figs. 1–6.

Barbour, Erwin Hinckley—Continued

1915.2 A New Nebraska Mammoth, Elephas hayi. Amer. Journ. Sci., (4), XL, No. 236, August, pp. 129–134, text figs. 1–5.
New species: *Elephas hayi*. Compared with *E. imperator*. Brief mention of *Elephas hayi* together with figure of type jaw (see article by Professor Barbour in Sunday State [Nebraska] Journal, January 3, 1915, "Prehistoric Elephants in the Morrill Collections, the Nebraska State Museum, the University of Neb.").

1915.3 Nebraska Fossils which Excite Common Inquiry. Neb. Geol. Surv., IV, Pt. 22, Oct. 1, pp. 303–324, text figs. 1–30.
Mastodons and Mammoths, pp. 319–322.

1915.4 A New Mammoth, Elephas hayi, from Crete, Nebraska. Neb. Geol. Surv., IV, Pt. 23, Sept. 15, pp. 327–331, Pls. I, II, text figs. 1–4.

1916.1 A New Longirostral Mastodon from Nebraska, Tetrabelodon osborni, sp. nov. Amer. Journ. Sci., (4), XLI, June, pp. 522–529, text figs. 1–4.
New species: *Tetrabelodon osborni*.

1917.1 The Boyd County Mastodon, Tetrabelodon osborni. Neb. Geol. Surv., IV, Pt. 30, Feb. 20, pp. 499–512, text figs. 1–12.
New genera: *Genomastodon* and *Mastelephas*. *Megabelodon* raised to rank of a genus.

1925.1 Elephas scotti. A New Primitive Mammoth from Nebraska. Neb. State Mus., Bull. 2, I, April 20, pp. 21–24, text figs. 7–11.
New species: *Elephas scotti*.

1925.2 Tetrabelodon abeli, Sp. Nov. Neb. State Mus., Bull. 9, I, August, pp. 91–94, text figs. 52–57.
New species: *Tetrabelodon abeli*.

1925.3 Skeletal Parts of the Columbian Mammoth, Elephas maibeni, sp. nov. Neb. State Mus., Bull. 10, I, August 30, pp. 95–118, text figs. 58–87.
New species: *Elephas maibeni*.

1926.1 Archidiskodon maibeni. Neb. State Mus., Bull. 11, I, July 10, pp. 119–122, text fig. 88.
First described as *Elephas maibeni* [see Barbour, 1925.3].

1927.1 Preliminary Notice of a New Proboscidean Amebelodon fricki, gen. et sp. nov. Neb. State Mus., Bull. 13, I, June 15, pp. 131–134, text figs. 89–91.
New family: Amebelodontidæ, p. 131. New genus: *Amebelodon*, p. 131. New species: *Amebelodon fricki*, p. 131.

1929.1 The Mandibular Tusks of Amebelodon fricki. Neb. State Mus., Bull. 14, I, December, pp. 135–138, text fig. 92.

1929.2 The Mandible of Amebelodon fricki. Neb. State Mus., Bull. 15, I, December, pp. 139–146, text figs. 93–97.
New subfamily: Amebelodontinæ, p. 139.

1929.3 Torynobelodon loomisi, gen. et sp. nov. Neb. State Mus., Bull. 16, I, December, pp. 147–153, text figs. 98–100.
New species: *Torynobelodon loomisi*.

1930.1 Amebelodon sinclairi sp. nov. Neb. State Mus., Bull. 17, I, January, pp. 155–158, text fig. 101.
New species: *Amebelodon sinclairi*.

1931.1 The American Mastodon with Mandibular Tusks. Neb. State Mus., Bull. 19, I, March, pp. 163–170, text figs. 103–108.

1931.2 A New Amebelodont, Torynobelodon barnumbrowni, sp. nov. A Preliminary Report. Neb. State Mus., Bull. 22, I, August, pp. 191–198, text figs. 123–126.
New species: *Torynobelodon barnumbrowni*.

1931.3 The Milford Mastodon, Mastodon moodiei, sp. nov. A Preliminary Report. Neb. State Mus., Bull. 24, I, December, pp. 203–210, text figs. 130–134.
New species: *Mastodon moodiei*.

1932.1 The Articulated Skeleton of Eubelodon morrilli. Neb. State Mus., Bull. 28, I, March, pp. 243–246, text figs. 152, 153.

1932.2 The Mandible of Torynobelodon barnumbrowni. Amer. Journ. Sci., (5), XXIV, September, pp. 214–220, text figs. 1–3.

1932.3 The Skull and Mandible of Mastodon moodiei. Neb. State Mus., Bull. 29, I, October, pp. 247–250, text figs. 154, 155.

1932.4 The Mandible of Platybelodon barnumbrowni. Neb. State Mus., Bull. 30, I, October, pp. 251–258, text figs 156–161.
Determined by Professor Osborn and Dr. Granger as belonging to *Platybelodon* rather than to *Torynobelodon*. [See Chap. X, p. 470, of present Memoir, where it is restored by Osborn to its original determination, namely, to *Torynobelodon*.]

1934.1. The Thurston County Mastodon, Mastodon grangeri, sp. nov. Neb. State Mus., Bull. 35, I, May, pp. 287–290, text fig. 170.
Mentions the discovery in Otoe County of the first example of *Mastodon americanus*, showing large helical tusks, from the State of Nebraska.

1934.2 A Mounted Skeleton of Megabelodon lulli. Neb. State Mus., Bull. 39, I, June, pp. 303–310, text figs. 177–181.

Barbour, Erwin Hinckley, and George F. Sternberg

1935.1 Gnathabelodon thorpei, gen. et sp. nov. A new mud-grubbing Mastodon. Neb. State Mus., Bull. 42, I, May, pp. 395–404, text figs. 187–191.
New subfamily: Gnathalodontinæ [Gnathabelodontinæ]. New genus: *Gnathabelodon*. New species: *Gnathabelodon thorpei*.

Baretti, Martino

1881.1 Resti Fossili di Mastodonte nel territorio d'Asti. Atti Accad. Sci. Torino, XVI, pp. 616–618.

Bartholomew, John G., W. Eagle Clarke, and Percy H. Grimshaw

1911.1 Atlas of Zoogeography. Bartholomew's Physical Atlas, Vol. V, Edinburgh.
Elephantidæ, pp. 20, 21, Pl. VII, map 1.

Bate, Dorothea Minola Alice

1903.1 Preliminary Note on the Discovery of a Pigmy Elephant in the Pleistocene of Cyprus. Proc. Roy. Soc. London, LXXI, No. 475, pp. 498–500.
New species: *Elephas cypriotes*.

1904.1 Further Note on the Remains of Elephas cypriotes from a Cave-Deposit in Cyprus. Phil Trans. Roy. Soc. London, CXCVII, B, pp. 347–360, Pls. XXI, XXII.

1907.1 On Elephant Remains from Crete, with Description of Elephas creticus, sp. n. Proc. Zool. Soc. London, March 5, pp. 238–250, Pls. XII, XIII, text fig. 83.
New species: *Elephas creticus*.

Bather, Francis Arthur

1927.1 The Upnor Elephant. Nat. Hist. Mag., I, No. 4, October, pp. 99–106, text figs. 1–6.
Elephas antiquus [=*Palæoloxodon antiquus andrewsi* of the present Memoir].

Baur, Georg

1889.1 Bemerkungen über den Carpus der Proboscidier und der Ungulaten im Allgemeinen. Morphol. Jahrb., XV, Heft III, pp. 478–482, Taf. XVII, text fig.

Beadnell, Hugh John Llewellyn

1902.1 See Andrews, Charles William, and Hugh John Llewellyn Beadnell.

Beck, Richard

1906.1 Mastodon in the Pleistocene of South Africa. Geol. Mag., Dec. V, N.S., III, February, pp. 49, 50, text fig.
Mastodon (subdivision *Bunolophodon*) in South Africa, Waldeck Plant, near Kimberley, Vaal River gravels, 60–80 foot terrace.

Beddard, Frank Evers

1893.1 On the Brain of the African Elephant. Proc. Zool. Soc. London, pp. 311–315, Pls. XXII, XXIII.
Young male that died in the Society's Gardens, Jan. 15, 1893.

Beechey, Frederick William

1831.1 Narrative of a Voyage to the Pacific and Beering's Strait, to co-operate with the Polar Expeditions: performed in His Majesty's Ship Blossom, under the command of Captain F. W. Beechey, R.N., F.R.S., etc. in the years 1825, 26, 27, 28. Published by authority of the Lords Commissioners of the Admiralty. I, II, 8vo, London.
Appendix by William Buckland entitled "On the occurrence of the remains of Elephants, and other Quadrupeds, in the cliffs of frozen mud, in Eschscholtz Bay, within Beering's Strait, and in other distant parts of the shores of the Arctic seas," Vol. II, pp. 331–356, Pls. I–III.
Elephant Point.

Belĭaeva, E.

1928.1 See Borissiak, Alexei Alexievich, and E. Belĭaeva.

Bell, Robert

1898.1 On the Occurrence of Mammoth and Mastodon Remains around Hudson Bay. Bull. Geol. Soc. Amer., IX, pp. 369–390, text fig.

Bensted, W. H.

1861.1 Remains of American "Missourium" associated with Flint Implements. Geologist, IV, pp. 217–221, 262.

Berckhemer, Fritz

1929.1 Bericht über die Tagung der Palaeontologischen Gesellschaft in Stuttgart und Tübingen. Palaeont. Zeitschr., XI, Heft III, Nov. 21, pp. 185–193.

Description of two skulls of *Elephas antiquus*, one found in 1926, the other in 1928, at Steinheim a. d. Murr, pp. 188–190.

1930.1 "Der Waldelefant" von Steinheim an der Murr. Aus der Heimat, November, pp. 331–337, text figs. 1–6.

Discovery of cranium of *Elephas antiquus*.

Berro, A. C.

1928.1 Un nuevo Mastodon en la R. O. del Uruguay. Mercedes. (*Fide* Cabrera, 1929, p. 141; original not available.)

New species: *Mastodon andium Kraglievichii*.

Beyer, Samuel Walker

1899.1 Geology of Story County. Iowa Geol. Surv., IX, pp. 157–237.

Elephas primigenius, Polk City, p. 211.

Beyschlag, Joannes Fridericus

1734.1 Dissertatio Inauguralis Physico-Medica de Ebore Fossili Sueuico Halensi. Halæ Magdeburgicæ.

Bieber, V.

1884.1 Ein Dinotherium-Skelet aus dem Eger-Franzensbader Tertiärbecken. Verh. geol. Reichsanst., No. 15, Oct. 31, pp. 299–305. Wien.

Lignites of northwest Bohemia, deposits rich in *Dinotherium* remains, also vast numbers of *Cypris angusta*. (Reuss, 1884.) (?)Miocene.

Biedermann, W. G. A.

1873.1 Petrefacten aus der Umgegend von Winterthur. Winterthur. (*Fide* Vacek, 1877, p. 3; original not available.)

Mastodon angustidens.

1876.1 Mastodon angustidens Cuv. Abh. schweiz. pal. Ges., III, pp. 1–7, Taf. I, II.

Billings, Elkanah

1863.1 On the remains of the Fossil Elephant found in Canada. Canad. Nat. Geol., (1), VIII, pp. 135–147, text figs. 1–5.

Euelephas jacksoni (Brigge and Foster).

Bishop, Carl W.

1921.1 The Elephant and Its Ivory in Ancient China. Journ. Amer. Oriental Soc., XLI, Pt. 4, October, pp. 290–306. New Haven.

Bishop, Sherman C., and Chris Andrew Hartnagel

1923.1 See Hartnagel, Chris Andrew, and Sherman C. Bishop.

Blainville, Henri Marie Ducrotay de

1837.1 Note sur la Tête de Dinotherium giganteum, actuellement à Paris. Compt. Rend. Acad. Sci., IV, No. 12, pp. 421–426, 2 text figs. Paris.

Communication on the same subject by André Marie Constant Duméril, p. 427, and by Isidore Geoffroy Saint-Hilaire, pp. 429, 430.

1837.2 Über den Schädel des Dinotherium giganteum. Neues Jahrb. Min., pp. 361–363.

Discussion by Duméril, Robert, Kaup, and Strauss.

1839-1864 Ostéographie ou Description Iconographique comparée du Squelette et du système Dentaire des Mammifères. III, Quaternatès, avec Atlas de 54 planches. Paris.

New species and subspecies: *Dinotherium intermedium*, *E. primigenius germanicus*, *E. indicus ceylanicus*, *E. indicus bengalensis*, *E. primigenius sibiricus*, *E. primigenius meridionalis*.

The dates of Blainville's various livraisons are given by C. Davies Sherborn in the Ann. Mag. Nat. Hist., (7), II, 1898, p. 76, under the title "Dates of Blainville's 'Ostéographie.'" Livraison 16 is on *Elephas* [and *Mastodon*], pp. 1–367, and 17 on *Dinotherium*, pp. 1–64, of date 1845.

Blake, Charles Carter

1861.1 On the Distribution of Mastodon in South America. Geologist, IV, pp. 469–472.

Elephas texianus especially. [Name appeared in Owen, 1859.1.]

1862.1 On a Fossil Elephant from Texas (E. Texianus). Geologist, V, pp. 57, 58, Pl. IV.

Definition of *Elephas texianus*, with figure, the "Bollaert molar."

1863.1 Elephas Texianus v. Columbi. Geologist, VI, pp. 56–60, text fig.

Reply to Dr. Falconer in regard to *E. texianus* and *E. columbi*.

Blake, John Frederick

1902.1 List of Types and Figured Specimens in the Collection of the Geological Society of London, with Appendix. 8vo, London, pp. 100+xxii.

Blake, William Phipps

1855.1 Remains of the Mammoth and Mastodon in California. Amer. Journ. Sci., (2), XIX, p. 133.

Elephas primigenius, San Pedro Bay, Calif.; *Mastodon americanus*, Calaveras County.

1864.1 Note on the Fossil remains of the Horse and Elephant, mingled, at Mare Island, San Francisco Bay. Proc. Calif. Acad. Nat. Sci., III, p. 166.

Species not determined.

1867.1 Notice of Fossil Elephants' Teeth from the Northwest Coast. Proc. Calif. Acad. Nat. Sci., III, p. 325.

1900.1 Remains of the Mammoth in Arizona. Amer. Geol., XXVI, p. 257.

Upper jaw and teeth, also lower molar, and fragment of tusk.

Blanc, Edouard

1897.1 Sur les Éléphants du Nord de l'Afrique et de la Haute-Égypte. Bull. Soc. Zool. France, XXII, pp. 47–54.

Blanckenhorn, Max

1904.1 Oberpliocän mit Mastodon arvernensis auf Blatt Ostheim vor der Rhön. Jahrb. geol. Landesanst. Berlin, XXII, pp. 364–371, Taf. VIII.

Blanford, William Thomas

1869.1 On the Geology of the Taptee and Lower Nerbudda valleys and some adjoining districts. Mem. Geol. Surv. India, VI, pp. 163–384, Pls. V–VIII, text figs. 1–16.

Ossiferous gravels and other old alluvial deposits, pp. 65–75.

1876.1 The African Element in the Fauna of India: a Criticism of Mr. Wallace's views as expressed in the 'Geographic Distribution of Animals.' Ann. Mag. Nat. Hist., (4), XVIII, No. 106, October, pp. 277–294, map.

1876.2 On the Geology of Sind. Rec. Geol. Surv. India, IX, pp. 8–22.

Derivation of the names Manchhar and Gaj, p. 9, with the stratigraphy of these two formations.

1878.1 On the Geology of Sind, (Second Notice). Rec. Geol. Surv. India, XI, pp. 161–173.

Nari, Gaj, and Manchhar groups, also general sequence of Tertiary beds in Sind.

1888–1891. The Fauna of British India. Mammalia. 8vo, London, Calcutta, Bombay, Berlin, pp. i–vi+iii–xx+617.

Proboscidea, Elephantidæ, *Elephas maximus*, pp. 462–467.

Blatchley, Willis Stanley

1898.1 The Geology of Lake and Porter Counties, Indiana. 22d Ann. Rept. Geol. and Nat. Resources for 1897, Indiana, pp. 25–104, Pls. I–VII, text figs. 1–9, map.

Mammoth and Mastodon, p. 89.

Blumenbach, Johann Friedrich

1779.1 Handbuch der Naturgeschichte. 2 Theile, pp. xi+559 [27], 2 pls. 8vo, Göttingen. Erster Theil (1779); Zweyter Theil (1780).

Elephas Maximus, p. 130. Mammontovaiakost, p. 548.

[(C. W. Andrews, letter June, 6, 1922): "The name *Mammut ohioticum* is not used in the first edition (the date of the second part is 1780 not 1779). . . . I cannot find the figure used in any of the works before the Abbildungen of 1797."]

1797.1 Handbuch der Naturgeschichte. Fünfte Auflage, pp. xviii+714 [32], 2 pls. 8vo, Göttingen.

Elephas asiaticus, p. 124; *Elephas africanus*, p. 125; Mammontovaiakost, p. 703.

1797.2 Abbildungen naturhistorischer Gegenstände. Heft II, Nos. 11–20, Göttingen. First edition, Hefte I–X, 1796–1803.

Ohio-Incognitum, Asiatic Elephant (*Elephas asiaticus*), African (*africanus*).

[The name *Ohio-Incognitum* first occurs on the back of the title page following other specific names: 11. "*Simia troglodytes* . . . 19. Backenzähne vom fossilen *Ohio-Incognitum*, und von den beiderlei Gattungen des Elephantengeschlechts." The name occurs again opposite the excellent figure 19.4. This name is listed in Italics with other specific names and cited by de Blainville (1839–1864) as the first specific name to be applied to this animal.

[In a letter from C. W. Andrews, (June 6, 1922) he quotes C. Davies Sherborn as follows: "The words 'Ohio incognitum' are not used in a generic or specific sense; they mean simply 'the Ohio incognitum' as is easily seen by the second page of the description, and are quite invalid."]

[See, however, Blainville's "Ostéographie," 1839–1841, p. 245, in which "*Ohio incognitum*, 1797," also "*Mammouth Ohioticum*" are cited among the synonyms of "Le Grand Mastodonte."]

Blumenbach, Johann Friedrich—Continued

1799.1 Handbuch der Naturgeschichte. Sechste Auflage, 8vo, Göttingen, pp. xvi+708 [32], 2 pls.

Elephas asiaticus, p. 121; *Elephas africanus*, p. 122; *Elephas primigenius*, p. 697; *Mammut ohioticum*, p. 698.

(P. 697): "3) Von einem ungeheuer grossen Elephanten (Elephas *primigenius*?) [die vermeinten Riesenknochen**) unsrer ehrlichen Alten]; unter andern auch in Menge in Deutschland***). So z. B. das berüchtigte Elephantengerippe das 1695 bey Burg-Tonna im Gothaischen ausgegraben worden etc."

"** f. Voigts Magazin. V. B. I. St S. 16 u. f."

"*** (Kriegsr. Merk) *lettres sur les os fossiles d'elephans et de rhinoceros qui se trouvent en Allemagne* &c. I–III. St. Darmst. 1783 u. f. 4."

(Pp. 697, 698): "C) Völlig unbekannte. So zu Einem Beyspiel statt aller das colossalische Land-Ungeheuer der Vorwelt, das Mammut (Mammut *ohioticum*) dessen Gebeine besonders am Ohio in Nordamerica etc. in Menge ausgegraben werden; und das sich unter andern schon durch die eigne auffallende Form seiner enormen Backzähne (—*Abbild. n.h. Gegenst.* tab. 19.—) von der übrigen thierischen Schöpfung der Vorwelt, ausgezeichnet."

1803.1 Handbuch der Naturgeschichte. Siebente Auflage, 8vo, Göttingen, pp. xvi+734 [34], 2 pls.

Elephas primigenius, p. 722; *Mammut ohioticum*, p. 723.

1803.2 Manuel d'Histoire Naturelle, traduit de l'Allemand, de J. Fr. Blumenbach, par Soulange Artaud. 8vo, Metz, I, pp. xvi+512; II, pp. iii+472.

Elephas asiaticus, p. 153; *Elephas africanus*, p. 155; *elephas primigenius*, p. 407; *mammout Ohioticum*, p. 408.

1810.1 Abbildungen naturhistorischer Gegenstände. Second edition.

See first edition above (1797.2). Hefte 1, 3, 4, and 5 *only* are of this second edition.

Blyth, Edward

1872.1 Wild Indian Elephants in Days of Yore. Zoologist, (2), VII, pp. 3169–3172.

Boas, Johan Erik Vesti, and Simon Paulli

1908, 1935. The Elephant's Head: Studies in the Comparative Anatomy of the Organs of the Head of the Indian Elephant and Other Mammals. Pts. I and II. Folio, Gustav Fischer, Jena.

Pt. I (1908), 79 pp. (1–79), 17 pls. (in color), 4 text figs.; Pt. II (1925), 51 pp. (81–131), 46 pls. (many in color).

Bocage, J. V. Barboza du

1890.1 Mammifères d'Angola et du Congo. Journ. Sci. Math. Phys. Nat. Lisboa, (2), II, No. V, pp. 1–32, Pl. I.

Bolk, Louis

1919.1 Zur Ontogenie des Elefantengebisses. Odontologische Studien, III. 8vo, Jena, 38 pp., 22 text-figs.

Bonaparte, Charles Lucien Jules Laurent

1838.1 Synopsis Vertebratorum Systematis. Nuov. Ann. Sci. Nat. Bologna, Anno I, Tom. II, pp. 105–133.

Places the family Elephantidæ, subfamily Elephantina, under the Order Belluæ, p. 112.

1839.1 Prodromus Systematis Mastozoologiæ, 8vo [Rome], 13 pp.

Order Belluæ, family Elephantidæ, subfamily Elephantina, p. 5.

1841 [1837] A New Systematic Arrangement of Vertebrated Animals. Trans. Linn. Soc. London, XVIII, pp. 247–304. (Read in 1837.)

Family Elephantidæ, the subfamilies Dinotherina and Elephantina, under the Order Belluæ, p. 253.

1845.1 Catalogo metodico dei Mammiferi Europei. Milan, 36 pp.

Dinotheridæ, p. 4 (*fide* Palmer, 1904, p. 738; original not available).

1849.1 On the Lorine Genus of Parrots, Eclectus, with the Description of a New Species, Eclectus Cornelia. Proc. Zool. Soc. London, XVII, pp. 142–146.

Elephas sumatranus in the Muséum d'Histoire Naturelle des Pays-Bas, Leiden, p. 144.

1850.1 Conspectus Systematis Mastozoologiæ. Mammalia. Folio, Lugduni Batavorum.

Dinotheriidæ (placed under Sirenia). Dinotheriina.

Borissiak, Alexei Alexievich

1928.1 On a new Mastodon from the Chokrak beds (Middle Miocene) of the Kuban region, Platybelodon Danovi, n. gen. n. sp. Ann. Soc. Paléont. Russie, VII, for the year 1927, January, pp. 105–120, Pl. VIII, text figs. 1, 2. In Russian language (summary in English).

New subfamily: Platybelodontinæ. New genus and species: *Platybelodon Danovi*.

1929.1 On a New Direction in the Adaptive Radiation of Mastodonts. Palaeobiologica, II, pp. 19–33, Taf. III–V, text figs. 1–4.

1929.2 Einige Fortschritte der russischen Paläontologie auf dem Gebiete der Wirbeltiere. Naturwis. Sowiet-Union. Vorträge ihrer Vertreter während der "Russischen Naturforscherwoche" in Berlin, 1927, 13 pp., 7 text figs.

Borissiak, Alexei Alexievich, and E. Beliaeva

1928.1 Trilophodon (Serridentinus?) inopinatus N. Sp. from the Jilančik Beds of the Turgai Region. Bull. Acad. Sci. U.S.S.R., Classe des Sci., Phys.-Math., pp. 241–252, Pls. I, II.

Borson, Étienne

1820.1 Mémoire sur des Mâchoires et des Dents du Mastodonte dit Mammouth, Trouvées Fossiles en Piémont. Mem. Accad. Sci. Torino, XXIV, pp. 160–176, Tav. I, II.

1823.1 Note sur des Dents du Grand Mastodonte trouvées en Piémont et sur des Mâchoires et Dents Fossiles Prises dans la Mine de Houille de Cadibona proche Savone. Mem. Accad. Sci. Torino, XXVII, pp. 31–42, Tav. II–V.

[Figure of molar tooth on which Hays founded *M. Borsoni*.]

Bortolotti, C.

1904.1 Denti di Proboscidati, di Rinoceronte e di Ippopotamo dell'antica collezione Canali in Perugia. Riv. ital. Pal., X, pp. 83–93, Tav. IV, V.

Botti, Ulderico

1891.1 La Grotta Ossifera di Cardamone in Terra D'Otranto. Boll. Soc. geol. Ital., IX, pp. 705–709, Tav. XXVI.

New species: *E. primigenius* Blum. var. *hydruntinus*.

Boué, Ami

1834.1 Résumé des Progrès des Sciences Géologiques pendant l'année 1833. Bull. Soc. géol. France, V, Deuxième Partie, pp. vii+507. Lu aux séances des 17 et 24 Février, et 7 Avril, 1834.

History of the term "Curtognati," p. 444.

Boule, Marcellin

1899.1 Les Mammifères quaternaires de l'Algérie, d'après les travaux de Pomel. L'Anthropologie, X, pp. 563–571.

Boule, Marcellin, and Armand Thevenin

1920.1 Mammifères Fossiles de Tarija. Miss. Sci. G. de Créqui-Montfort et E. Sénéchal de la Grange, pp. vii+255, 26 pls., frontispiece, 65 text figs.

Proboscidea, pp. 17–74.

Bourg de Bozas, Robert

1903.1 D'Addis Abbabá au Nil par le lac Rodolphe. La Géographie, VII, No. 2, pp. 91–112, Pl. I.

Branco [Branca], Carl Wilhelm Franz, and Wilhelm Reiss

1883.1 See Reiss, Wilhelm, and Carl Wilhelm Franz Branco [Branca].

Brandt, Johan Friedrich

1833.1 Ueber die Existenz von sechs Arten vorweltlicher Elephanten, die im Zahnbau dem asiatischen Elephanten ähneln. Mém. Acad. Imp. Sci. St. Pétersb., (6), II, Math. et Phys., Bull. Sci., No. 2, pp. x–xv.

New species: *Elephas brachyramphus*, p. xi, *Elephas giganteus*, p. xii, *Elephas commutatus*, p. xii, *Elephas stenotoechus*, p. xiii, *Elephas platytaphrus*, p. xiv; *homotaphrus* is mentioned (p. xii) but no description is given. *Elephas affinis* is also mentioned, p. xiv; [apparently the specific name first appears in Isis, 1832, p. 1112, in an anonymous article signed "Ein Naturforscher in St. Petersburg" and is attributed by the writer to "Herr B." Herr Brandt?].

1860.1 Erster Bericht der südrussischen zoologisch-paläontologischen Expedition. Bull. Acad. Imp. Sci. St. Pétersb., II, pp. 502–511, Tab.

Mastodon-Skelet von Woskressensk (Gouv. Cherson).

1869.1 De Dinotheriorum genere Elephantidorum familiae adjungendo nec non de Elephantidorum generum craniologia comparata. Mém. Acad. Imp. Sci. St. Pétersb., (VII), XIV, No. 1, pp. 1–37.

History of the literature on the Dinotheriidæ and classification of the Proboscidea, including especially first use of Mastodontina.

Brauns, David August

1881.1 Geology of the Environs of Tokio. Memoirs of the Science Department Tokio Daigaku (University of Tokio), N. 4, Tokio, 2541 [Japanese year = 1881], pp. v–vii, 1–82, Pls. I–VIII.

Elephas meridionalis, *E. antiquus*.

1883.1 Ueber japanische diluviale Säugethiere. Zeitschr. deutsch. geol. Ges., XXXV, pp. 1–58, Taf. I. Berlin.

Brayley, Edward William

1831.1 On the Odour exhaled from certain Organic Remains in the Diluvium of the Arctic Circle. Phil. Mag., IX, pp. 411–418.

[In a review (evidently by Bronn), Neues Jahrb. Min. Geogn. Geol., 1833, pp. 370-372, the name *Elephas primordialis* occurs; it does not appear in the original article by Brayley. Bronn, however, in his "Handbuch einer Geschichte der Natur," III, p. 455, attributes this name to Brayley. See Tilesius, 1815, p. 470, who attributes it to Blumenbach].

Breislak, Scipione

1820.1 Lehrbuch der Geologie. 2ter Band, 8vo, Braunschweig, 703 pp., text fig.

Elephant molar from Thiede, Thuringia [Kruger's type of *Elephas antiquitatis*].

Breuil, Henri

1911.1 Les Cavernes de la Région Cantabrique (Espagne). Publiées sous les Auspices de S.A.S. le Prince Albert I^er^ de Monaco. (With H. Alcalde del Rio and Lorenzo Sierra. Plates and figures by l'Abbé Breuil.)

Breuil, Henri, Joseph-Louis Capitan, and D. Peyrony

1924.1 See Capitan, Joseph-Louis, Henri Breuil, and D. Peyrony.

Breyne, John Philip

1741.1 A Letter from John Phil. Breyne, M.D. F.R.S. to Sir Hans Sloane, Bart. Pres. R. S. with Observations, and a Description of some Mammoth's Bones dug up in Siberia, proving them to have belonged to Elephants. Phil. Trans. Roy. Soc. London, XL, for the years 1737 and 1738, No. 446, pp. 124–138, Pls. I, II, III.

[Pls. I and II are of Messerschmidt's Siberian skulls of the Mammoth.]

Briggs, Caleb, Jr.

1838.1 Report of C. Briggs . . . Mammoth, or Fossil Elephant. 1st Ann. Rept. Geol. Surv. Ohio, pp. 96–98.

Salt Creek, northwestern part of Jackson County. [See Mather, W. W., 1838.1.]

1838.2 Bones of the Mastodon. 2d Ann. Rept. Geol. Surv. Ohio, pp. 127–129.

Britton, Nathaniel Lord

1885-1886. Remarks on finding of mastodon remains east of the Hudson River; followed by remarks by Prof. D. S. Martin and Dr. O. P. Hubbard. Trans. New York Acad. Sci., V, pp. 14. 15.

Brives, Abel

1919.1 Sur la découverte d'une dent de Dinotherium dans la sablière du Djebel Kouif, près Tébessa. Bull. Soc. Hist. Nat. Afrique du Nord, X, May 15, pp. 90–93, text fig.

Broadhead, Garland Carr

1881.1 The Mastodon. Kansas City Rev. Sci. Indust., IV, pp. 519–530.

Localities in North America.

Bronn, Heinrich Georg

1848.1 See von Meyer, Hermann, and Heinrich Robert Göppert.

1853–1856. Lethaea Geognostica. . . . Dritte . . . Auflage, bearbeitet von H. G. Bronn and F. Roemer, III, 1130 pp. Stuttgart.

Dinotherium, pp. 803–809; *Elephas*, pp. 809–820; *Mastodon*, pp. 820–832.

Broom, Robert

1928.1 Mammoths and Man in the Transvaal. Nature, CXXI, No. 3044, March 3, p. 324.

Refers to *Archidiskodon* molars described by Dart (*Archidiskodon transvaalensis*, *A. sheppardi*) and undescribed molars of *Archidiskodon* [subsequently described by Osborn, Nature, April 28, 1928, pp. 672, 673, as *Archidiskodon subplanifrons* and *A. broomi*]. See also Osborn, 1931.925.

Brown, Barnum

1908.1 The Conard Fissure, A Pleistocene Bone Deposit in Northern Arkansas; with Descriptions of Two New Genera and Twenty New Species of Mammals. Mem. Amer. Mus. Nat. Hist., IX, Pt. IV, pp. 157–208, Pls. XIV–XXV, text figs. 1–3.

Comparison of cave fauna, showing absence of the Mammoth and Mastodon in the Conard Fissure and presence in Port Kennedy Cave, Pa.

Brown, C. Emerson

1934.1 Captive Pigmy Elephants in America. Journ. Mamm., XV, No. 3, August, pp. 248–250.

Buckland, William

1828.1 Geological Account of a Series of Animal and Vegetable Remains and of Rocks, collected by J. Crawfurd, Esq. on a Voyage up the Irawadi to Ava, in 1826 and 1827. Trans. Geol. Soc. London, (2), II, Pt. III, pp. 377–392, Pl. XLIV.

1831.1 On the occurrence of the Remains of Elephants, and other Quadrupeds, in the cliffs of frozen mud, in Eschscholtz Bay, within Beering's Strait, and in other distant parts of the shores of the Arctic seas. In Beechey's Narrative of a Voyage to the Pacific and Beering's Strait to co-operate with the Polar Expeditions: performed in His Majesty's Ship Blossom, under the command of Captain F. W. Beechey, R.N., F.R.S., etc. in the years 1825, 26, 27, 28. Appendix to Vol. II, pp. 331–356, Pls. I–III.

1835.1 Über den Bau und die mechanische Kraft des Unterkiefers des Dinotherium. Neues Jahrb. Min., pp. 516–518.

Buckley, Thomas Edward

1876.1 On the Past and Present Geographical Distribution of the Large Mammals of South Africa. Proc. Zool. Soc. London, March 7, pp. 277–293.

Elephas africanus, pp. 279, 280.

Buffon, Georges Louis Leclerc de

1778.1 Histoire Naturelle, Générale et Particulière. Supplement, V, Des Epoques de la Nature, pp. viii+615+xxviii, 6 pls., map.

Figures the tooth from the Ohio River sent to him by Collinson (Pl. IV) also that presented to him by le Comte de Vergennes, found in "la petite Tartarie" (Russia). Pls. I, II. Plate III represents a smaller molar reported from Siberia by l'Abbé Chappe.

1784.1 L'epoche della natura, II, Venezia. (*Fide* Vacek, 1877, p. 6; original not available.)

Burmeister, Hermann

1837.1 Handbuch der Naturgeschichte. Abth. I and II, Berlin. (Original not available.)

New genus: *Gomphotherium*, p. 795 (*fide* Palmer, letter, Oct. 20, 1920).

1851.1 Geschichte der Schöpfung. (*Fide* Weinsheimer, 1883, p. 11; original not available.)

Regards *Dinotherium* as an herbivorous sea monster.

1866.1 Lista de los Mamiferos Fosiles del Terreno Diluviano. An. Mus. Públ. Buenos Aires, I (1864–1869), pp. 121–300, Lám. V–XIV; Actas Soc. Palcont. Buenos Aires.

Mastodon humboldtii [=*Cuvieronius superbus*], p. 288.

1879.1 Description Physique de la République Argentine, III, 8vo, Buenos Aires, pp. vi+555.

Mastodon humboldtii and *Mastodon antium*, pp. 522, 523.

1888.1 Bericht über Mastodon Antium. Sitz.-Ber. Akad. Wiss. Berlin, pp. 717–729.

1889.1 Los Caballos Fósiles de la Pampa Argentina. Suplemento, pp. V, VI, 1–65, Lám. IX–XII. Folio, Buenos Aires.

Burnett, Gilbert Thomas

1829.1 Illustrations of the Quadrupeda, or Quadrupeds, being the arrangement of the true four-footed Beasts indicated in outline. Quart. Journ. Sci., London, July to December, pp. 336–353.

Mammuthus borealis (Fossil Mammoth), p. 352.

Busk, George

1867.1 Description of the Remains of three extinct Species of Elephant, collected by Capt. Spratt, C.B., R.N., in the Ossiferous Cavern of Zebbug, in the Island of Malta . . . partly from the Notes of the late H. Falconer, M.D., F.R.S. Trans. Zool. Soc. London, VI, Pt. V, pp. 227–306, Pls. XLIV–LIII.

New species: *Elephas falconeri* [=*Palaeoloxodon* (*Pilgrimia*) *falconeri*].

1868.1 See Adams, Andrew Leith.

Buwalda, John Peter

1914.1 A Proboscidean Tooth from the Truckee Beds of Western Nevada. Bull. Dept. Geol. Univ. Calif., VIII, No. 16, pp. 305–308, fig. 1. Issued Dec. 22, 1914.

[Fragment of a bunomastodont lower molar.]

Cabrera, Ángel

1927.1 Sobre el origen y significación del entrecruzamiento de las defensas en algunos elefantes. Bol. Soc. españ. hist. nat., XXVII, pp. 441–449, text figs. 1, 2. Madrid.

Two views of Indian elephant showing crossing of tusks.

Cabrera, Ángel—Continued

1929.1 Una Revisión de los Mastodontes Argentinos. Rev. Mus. La Plata, XXXII, pp. 61–144, Lám. I, II, text figs. 1–35.

New family: Gomphotheriidæ. New subfamily classification: Rhynchotheriinæ (=Rhynchorostrinæ of Osborn); Gomphotheriinæ (="Tetralophodonts" and "Serridentines" of Osborn); Cuvieroniinæ (=Notorostrinæ, in part, of Osborn); Anancinæ (=Notorostrinæ, in part, and Brevirostrinæ, of Osborn). Abandonment of specific name *humboldtii*. Reference of *M. platensis* and *M. superbus* to *Stegomastodon*. New genus: *Notiomastodon*. New species: *Notiomastodon ornatus*.

Cacciamali, G. B.

1890.1 Gli elefanti fossili di Val di Comino. Boll. Soc. Geol. ital., IX, pp. 46–49, text figs. 1, 2. Rome.

Elephas antiquus and *E. primigenius*.

1890.2 Gli elefanti fossili di Aquino. Boll. Soc. Geol. ital., IX, pp. 423, 424, text figs. 1, 2. Rome.

Elephas antiquus and *E. meridionalis*.

Calvin, Samuel

1909.1 Aftonian Mammalian Fauna. Bull. Geol. Soc. Amer., XX, pp. 341–356, Pls. XVI–XXVII.

Elephas imperator, E. columbi, Mastodon mirificus [Pl. XXVII, type molar of *Stegomastodon aftoniæ* Osborn], *Mammut americanum*.

1911.1 Aftonian Mammalian Fauna II. Bull. Geol. Soc. Amer., XXII, pp. 207–216, Pls. XVIII–XXIV.

Elephas columbi most common of the Aftonian elephants; *Elephas indianapolis* = *Elephas mississippiensis; Mastodon americanus*. [Original figure of Hay's type of *Mastodon progenium*, Pls. XX, XXI, figured by Calvin as *Mastodon americanus*.]

Camper, Peter

1788 [1787] Complementa varia Academiae Imperialis Scientiarum Petropolitanae communicanda, ad Clar. ac Celeb. Pallas. Nova Acta Acad. Sci. Imp. Petropol., II, for the year 1784, pp. 250–264.

Genus: *Mammonteum* [=*Mammonteus*], p. 251.

1803.1 Description Anatomique d'un eléphant Mâle, pp. xii+108. Atlas.

Notes of Peter Camper, 1722–1789, published by his son Adrian Gilles Camper in 1802; text not available to the present author. Atlas of 1803, with 21 plates, in the American Museum General Library.
New species: *Elephas macrocephalus* [*fide* Sherborn, 1928.1, p. 3760].

Caneto, l'Abbé

1837.1 Dissertation sur le Dinotherium. Ann. Phil. Chrétienne (Nouvelle Série), XIV, No. 84, pp. 408–419, 1 pl.

Molar of *Dinotherium* discovered by Curé de Labastide in Gers and deposited in the Séminaire d'Auch, p. 410.

Cantamessa, Filippo

1891.1 Il Mastodonte di Cinaglio d'Asti ed il Mastodon arvernensis (Cro. et Job.); Osteografia ed Osservazioni. Mem. Accad. Sci. Torino, (2), XLI, pp. 339–379.

Capellini, Giovanni

1888.1 Sui resti di Mastodon arvernensis recentemente scoperti a Spoleto, Pontremoli e Castrocaro. Mem. Accad. Sci. Bologna, (4), IX, pp. 1–10, Tav. I, II.

1893.1 Resti di Mastodonti nei depositi marini pliocenici della provincia di Bologna. Mem. Accad. Sci. Bologna, (5), III, pp. 163–170, Tav.

Mastodon arvernensis.

1907-1908 Mastodonti del museo geologico di Bologna. Mem. Accad. Sci. Bologna, I, (6), IV, pp. 127–145; II, (6), V, pp. 29–39, Tav. I, II.

Mastodon arvernensis.

Capitan, Joseph-Louis, Henri Breuil, and D. Peyrony

1924.1 Les Combarelles aux Eyzies (Dordogne). Inst. Pal. Humaine, Masson et Cie, Paris, 189 pp., 58 pls., 127 text figs.

Palæolithic representations of the Mammoth on walls of cavern.

Carette, Eduardo

1919.1 Los Proboscideos Fósiles Argentinos. Primera Reunión Nacional de la Sociedad Argentina de Ciencias Naturales, Tucumán, pp. 166–180, Lám. XI, XII.

Phylogeny. Type figure of Moreno's *Mastodon bonaerensis*.

Carles, Enrico de

1888.1 Noticias sobre un viaje a Tarija (Bolivia). Bol. Inst. geog. Argentina, IX, pp. 35–40.

Carus, Julius Victor, and Carl Eduard Adolph Gerstaecker

1868.1 Handbuch der Zoologie. I, Leipzig. (*Fide* Weinsheimer, 1883, p. 12; Brandt, 1869, p. 7.)

See p. 140 for remarks on *Dinotherium*.

Case, Ermine Cowles, and George M. Stanley

1935.1 The Bloomfield Mastodon. Bull. Cranbrook Inst. Sci., No. 4, October, pp. 1–8, text figs. 1, 2, Pls. I–III, frontispiece.

Castellanos, Alfredo

1921.1 La Presencia del Hombre Fósil en el Pampeano Medio del Valle de Los Reartes (Sierra de Cordoba). Bol. Acad. Cien. Córdoba (Republica Argentina), XXV, pp. 369–382, Lám. I–VIII.

See especially Lám. VII and VIII, thought to be the tip of an incisor, artificially carved, of *Mastodon* [=*Cuvieronius superbus*].

1934.1 El Hombre Prehistorico en la Provincia de Cordoba (Argentina), Rev. Soc. "Amigos de la Arqueologia," VII, pp. 1–88, text figs. 1–23.

Figure of incisive tusk, artificially carved, of *Cuvieronius hyodon* [=*?Notiomastodon ornatus*].

Castelnau, Francis de

1855.1 See Gervais, François Louis Paul.

Caterini, Francesco

1923.1 Catalogo dei Proboscidiani pliocenici e quaternari conservati nel Museo di Geologia dell'Università di Pisa. Atti Soc. Toscana Sci. Nat., XXXV, pp. 195–210. text fig. Pisa.

Mastodon arvernensis, Elephas planifrons, E. meridionalis, E. ausonius, E. antiquus, E. primigenius, E. meltiensis.

Cautley, Proby Thomas

1834.1 Discovery of an Ancient Town near Behut, in the Doáb. Journ. Asiat. Soc. Bengal, III, January to December, pp. 43, 44.

On p. 527 is a letter from Capt. Cautley, giving additional particulars of the fossil bone deposit in the Sewálik hills (which apparently did not yield mammalian fossils near Behut, but in the Nahun deposits near Samrota, valley of the Pinjore).

1836.1 Note on the Teeth of the Mastodon à dents etroites of the Siwálik Hills. Journ. Asiat. Soc. Bengal, V, May, pp. 294–296, Pl. XI.

New species: *Mastodon Sivalensis*.

1836.2 Note on Mastodons of the Sewaliks. Journ. Asiat. Soc. Bengal, V, December, pp. 768–770, Pl. XL.

The editor adds in a postscript to this article that "A very perfect head of a horse has also just been extracted by the Sewalik working parties, from the hard sandstone."

1845-1847 See Falconer, Hugh, and Proby Thomas Cautley.

Champion, Frederick Waller

1928.1 Wild Elephants in the United Provinces. Journ. Bombay Nat. Hist. Soc., XXXII, Pt. I, Aug. 1, 1927, pp. 127–132, 4 pls. Madras.

Chaney, Ralph Works

1935.1 The Kucha Flora in Relation to the Physical Conditions in Central Asia during the late Tertiary. Hyllningsskrift tillägnad Sven Hedin på hans 70-Årsdag. 8vo, Stockholm, pp. 75–105, 3 pls., 11 text figs.

Chantre, Ernest

See Lortet, Louis, and Ernest Chantre for 1872 [1876] and 1879.

Chapman, James

1868.1 Travels in the Interior of South Africa. 8vo, London, I, pp. xvi+454; II, pp. xii+480.

Cheney, Theseus Apoleon

1872.1 The Chantauqua [Chautauqua] Mastodon. Amer. Naturalist, VI, pp. 178, 179.

Christy, Henry

1875.1 See Lartet, Édouard, and Henry Christy.

Chubb, Ernest Charles

1909.1 The Mammals of Matabeleland. Proc. Zool. Soc. London, I, No. VIII, Feb. 2, pp. 113–125.

Elephas africanus Blum. on page 125.

1919.1 A South African Elephant from the Addo Bush. Annals Durban Museum, II, Pt. III, March 31, pp. 126–128, Pls. XXI, XXII.

Claridge, W. Walton

1915.1 A History of the Gold Coast and Ashanti. 8vo, London, I, pp. xxxiv+649; II, pp. xv+638.

Clark, William Bullock, Arthur Hollick, and Frederic Augustus Lucas

1906.1 The Interpretation of the Palaeontological Criteria. Pliocene and Pleistocene Rept., Maryland Geol. Surv., December, pp. 139–152, Pls. xxxii, xxxiii. "The Elephants of the Pleistocene" by Frederic Augustus Lucas, pp. 149–152.

The name "Mamatu" used by the natives of Siberia for the Mammoth, according to Lucas.

Clark, William Bullock, George Burbank Shattuck, and William Healey Dall

1904.1 The Miocene Deposits of Maryland. Maryland Geol. Surv., Miocene, pp. xxiii–clv, Pls. i–ix.

See especially section by Shattuck, "Geological and Paleontological Relations, with a Review of Earlier Investigations," pp. xl and lxxviii, regarding the Choptank formation ['*M.*' *obscurus*?].

Clarke, John Mason

1903.1 Distribution of Mastodon Remains in New York. Science, N.S., XVII, No. 425, Feb. 20, p. 297.

1903.2 Mastodons of New York. A List of Discoveries of Their Remains 1705–1902. Rept. State Palæontologist, 1902, N. Y. State Mus., Bull. 69, pp. 921–933, Pls. i, ii, map.

Claudius, Matthias

1865.1 Das Gehörlabyrinth von Dinotherium giganteum nebst Bemerkungen über den Werth der Labyrinthformen für die Systematik der Säugethiere. Palaeontogr., XIII, pp. 65–74, Taf. xx.

Clift, William

1828.1 On the Fossil Remains of two New Species of Mastodon, and of other vertebrated Animals, found on the left Bank of the Irawadi. Trans. Geol. Soc. London, (2), II, Pt. III, pp. 369–375, Pls. xxxvi–xli.

New species: *Mastodon latidens*, *M. elephantoides*.

Colbert, Edwin Harris

1935.1 Siwalik Mammals in The American Museum of Natural History. Trans. Amer. Phil. Soc., N. S., XXVI, October, pp. i–x, 1–401, text figs. 1–198, 1 infolding map.

Proboscidea listed, p. 32; remarks, p. 129.
Nomina nuda (Osborn, ex MS.): *Trilophodon hasnotensis* and *Anancus properimensis*, p. 32; *Pentalophodon falconeri*, p. 33.

Colbert, Edwin Harris, and Henry Fairfield Osborn

1931.1 See Osborn, Henry Fairfield, 1931.858.

Collett, John

1882.1 Recent Extinction of the Mastodon. Amer. Naturalist, XVI, January, pp. 74, 75.

Collinson, Peter

1768.1 An Account of some very large Fossil Teeth, found in North America, and described by Peter Collinson, F.R.S. Phil. Trans. Roy. Soc. London, LVII, Pt. I, for the year 1767, pp. 464–467. Sequel to the foregoing, pp. 468, 469, Tab. xxi, xxii.

Teeth and bones sent over by George Croghan, Esq., Feb. 7, 1767, from Philadelphia, to Lord Shelburne and to Dr. Benjamin Franklin.

Cook, Harold James

1909.1 A New Proboscidean from the Lower Miocene of Nebraska. Amer. Journ. Sci., XXVIII, August, pp. 183, 184, text fig.

New species: *Gomphotherium conodon* [=*Dinohyus petersoni* Holland].

1914.1 Note on the Occurrence of the Mammoth in Sioux County, Nebraska. Neb. Geol. Surv., VII, Pt. 8, Bull. 50, pp. 47, 48. Pl. i.

Elephas ? columbi.

1922.1 Two New Bunomastodonts from Colorado. Proc. Colo. Mus. Nat. Hist., IV, No. 1, Feb. 15, pp. 1–15, text figs. 1–6.

New species: *Trilophodon hicksi*, *T. paladentatus* [both referred to *Amebelodon*].

1928.1 A New Longirostrine Elephant from Nebraska, Trilophodon phippsi, Sp. Nov. Proc. Colo. Mus. Nat. Hist., VIII, No. 4, May 1, pp. 37–43, Pls. i–iii.

1928.2 Note on an Interesting Juvenile Lower Jaw of Elephas cf. jeffersonii. Proc. Colo. Mus. Nat. Hist., VIII, No. 5, May 2, pp. 44, 45, text fig.

1930.1 Occurrence of Mammoth and Giant Bison in Glacial Moraines in the High Mountains of Colorado. Science, N.S., LXXII, No. 1855, July 18, p. 68.

Found near Tripler camp, twelve miles up from Cerro.

Cook, Harold James, and Oliver Perry Hay

1928.1, 1930.1 See Hay, Oliver Perry, and Harold James Cook.

Cook, Harold James, and William Diller Matthew

1909.1 See Matthew, William Diller, and Harold James Cook.

Cooke, Charles Wythe, and Stuart Mossom

1929.1 Geology of Florida. Ann. Rept. Fla. State Geol. Surv., XX, pp. 29–227.

Cooper, Clive Forster

1915.1 New Genera and Species of Mammals from the Miocene Deposits of Baluchistan. Preliminary Notice. Ann. Mag. Nat. Hist., (8), XVI, November, pp. 404–410, text figs. 1–5.

Comments on *Hemimastodon* and *Tetrabelodon* [=*Trilophodon*] *angustidens palæindicus*, and makes comparison with *Palæomastodon*.

1922.1 Miocene Proboscidia from Baluchistan. Proc. Zool. Soc. London, October, pp. 609–626, Pls. i–iv, text figs. 1–12.

1924.1 On the Skull and Dentition of Paraceratherium bugtiense: a Genus of Aberrant Rhinoceroses from the Lower Miocene Deposits of Dera Bugti. Phil. Trans. Roy. Soc. London, CCXII, B, pp. 369–394, text figs. 1–19. (Published Feb. 4.)

Shows bone bed at Chur-Lando.

1924.2 On Remains of Extinct Proboscidea in the Museums of Geology and Zoology in the University of Cambridge. Pt. I. Elephas antiquus. Proc. Cambridge Phil. Soc. (Biol. Sci.), I, No. 2, April, pp. 108–120, Pls. vi–x, text figs. 1–6.

Cooper, Clive Forster, and Charles William Andrews

1928.1 See Andrews, Charles William, and Clive Forster Cooper.

Cooper, William

1824.1 Account of the Discovery of a Skeleton of the Mastodon giganteum. Extracted from a Report made to the Lyceum of Natural History by Messrs. DeKay, Van Rensselaer, and Cooper. Read May 10, 1824. Ann. Lyc. Nat. Hist. New York, I, Pt. I, pp 143–147.

1831.1 Notices of Big-bone Lick. Month. Amer. Journ. Geol., I, No. 4, October, pp. 158–174, 205, 217. Philadelphia.

Includes the various explorations made there, the animals to which the remains belong, and the quantity that has been found of each, with a particular account of the great collection of bones discovered in September, 1830.

Cooper, William, J. A. Smith, and James Ellsworth DeKay

1831.1 Report of Messrs. Cooper, J. A. Smith, and DeKay, to the Lyceum of Natural History, on a collection of fossil bones, disinterred at Big Bone Lick, Kentucky, in September, 1830, and recently brought to New York. Amer. Journ. Sci., XX, No. 2, July, pp. 370–372.

Cope, Edward Drinker

1868.1 Synopsis of the Extinct Mammalia of New Jersey. Geology of New Jersey. George H. Cook, State Geologist, 1868, Appendix C, pp. 739–742.

Trilophodon ohioticus.

1871.1 Cave Mammals in Pennsylvania. Amer. Naturalist, V, p. 58.

Abstract. Finding of bones in Port Kennedy cave. *Trilophodon ohioticus*.

1871.2 The Port Kennedy Bone Cavern. Proc. Amer. Phil. Soc., XII, pp. 15, 16.

T. ohioticus.

1871.3 Preliminary Report on the Vertebrata discovered in the Port Kennedy Bone Cave. Proc. Amer. Phil. Soc., XII, pp. 73–102, text figs. 1–20.

M. americanus.

1872.1 Remarks on Mastodon from New Mexico. Proc. Acad. Nat. Sci. Phila., XXIV, Sept. 3, p. 142.

Mastodon obscurus, *M. sheppardi*.

1873.1 Synopsis of New Vertebrata from the Tertiary of Colorado obtained during the summer of 1873. Government Printing Office, Washington, Oct. 16, pp. 1–19.

New species: *Mastodon proavus*.

1874.1 Report on the Vertebrate Paleontology of Colorado. 7th Ann. Rept. U. S. Geol. and Geogr. Survey of the Territories (embracing Colorado) [for 1873, F. V. Hayden, U. S. Geologist], pp. 427–533, Pls. i–viii.

M. proavus, pp. 531, 532 especially.

Cope, Edward Drinker—Continued

1874.2 On the Homologies and Origin of the Types of Molar Teeth of Mammalia Educabilia. Journ. Acad. Nat. Sci. Phila., (2), VIII, pp. 71–89, text figs. 1–29.

1875.1 On a New Mastodon and Rodent. Proc. Acad. Nat. Sci. Phila., XXVI, 1874, issued Feb. 2, 1875, pp. 221–223.

New species: *Mastodon productus*.
Abstract "A New Mastodon," Amer. Naturalist, IX, 1875, p. 56.

1875.2 Synopsis of the Vertebrata whose Remains have been preserved in the Formations of North Carolina. Rept. Geol. Surv., No. Carolina, W. C. Kerr, State Geologist, Appendix B, pp. 29–52, Pls. v–viii.

Occurrence of *Mastodon americanus*, also of *M. obscurus* [=*Trilophodon obscurus*].

1875.3 Report on the Geology of that Part of Northwestern New Mexico examined during the field season of 1874. Ann. Report upon the Geogr. Explorations and Surveys West of the 100th Meridian . . . (Wheeler). Being Appendix LL of the Annual Report, Chief of Engineers for 1875, pp. 961–1097, Pls. ii, v, vi, text figs. 1–18. When Appendix LL, etc., was issued as a separate the pagination was 61–116. 8vo, Washington.

Mastodon productus, etc.

1877.1 Report upon the Extinct Vertebrata obtained in New Mexico by Parties of the Expedition of 1874. Report, U. S. Geogr. Surveys West of the 100th Meridian (Wheeler), IV, Pt. II, pp. xii+370, Pls. xxii–lxxxiii. 4to, Washington.

M. productus, pp. 306–316 especially, and type figure, Pl. lxx.

1877.2 On a New Proboscidean. Proc. Amer. Phil. Soc., XVI, March 19, pp. 584, 585. Also, Pal. Bull. No. 24, pp. 584, 585.

Cænobasileus tremontigerus, based on an artifact; both genus and species withdrawn by Cope in Amer. Naturalist, XXIII, p. 207.

1878.1 Descriptions of New Vertebrata from the Upper Tertiary Formations of the West. Proc. Amer. Phil. Soc., XVII, 1877, issued Jan. 12, 1878, pp. 219–231. Also, Pal. Bull. No. 28, pp. 219–231.

New species: *Tetralophodon campester*.
Abstract, "A New Mastodon," Amer. Naturalist, XII, Jan. 31, 1878, p. 128.

1879.1 The Relations of the Horizons of Extinct Vertebrata of Europe and North America. Bull. U. S. Geol. and Geogr. Survey of the Territories, V, No. 1, pp. 33–54.

Tetralophodon found in Loup Fork (America), *Dinotherium* in Falunian (Europe); *Elephas primigenius* in *Equus* beds (America), Astian (Europe); *Mastodon* sp. in *Megalonyx* beds (America), Plaisancian (Europe).

1880.1 Pliocene Man. [Remarks on fossil Vertebrates from California, *Elotherium*, *Mastodon obscurus*—Hay]. Amer. Naturalist, XIV, pp. 60–62.

1880.2 Hill's Kansas Expeditions. Amer. Naturalist, XIV, pp. 141, 142. (Unsigned.)

1880.3 On the Foramina perforating the Posterior Part of the Squamosal Bone of the Mammalia. Proc. Amer. Phil. Soc., XVIII, pp. 452–461, text figs. 1–6.

Elephas; no foramina, p. 457.

1881.1 Recent Extinction of the Mastodon. Amer. Naturalist, XVI, 1882, pp. 74, 75. (Unsigned. Cited by Hay.)

Refers to Prof. John Collett's "Geological Report of Indiana for 1880." Preservation of bones, fat, and stomach-contents in two Illinois skeletons.

1882.1 The Classification of the Ungulate Mammalia. Proc. Amer. Phil. Soc., XX, pp. 438–447, text figs. 1–10. Also, Pal. Bull. No. 35, pp. 438–447.

1883.1 [Contemporaneity of Man and Pliocene Mammals.] Proc. Acad. Nat. Sci. Phila., XXXIV, 1882, pp. 291, 292.

Elephas primigenius and a species of *Equus* are listed.

1884.1 The Mastodons of North America. Amer. Naturalist. XVIII, pp. 524–526.

New species: *Mastodon serridens*, *M. euhypodon*.

1884.2 The Extinct Mammalia of the Valley of Mexico. Proc. Amer. Phil. Soc., XXII, pp. 1–21. Also, Pal. Bull. No. 39, pp. 1–21.

New genera: *Dibelodon*, *Tetrabelodon*. New species: *Dibelodon tropicus*.

1885.1 The Vertebrate Fauna of the Ticholeptus Beds. Amer. Naturalist, XX, Mar. 23, pp. 367–369.

Mastodon proavus.

1886.2 The Origin of the Fittest. 8vo, D. Appleton and Co., New York, pp. xix+467, 18 pls., 81 text figs.

1888.1 Cenozoic Realm. Amer. Geologist, II, pp. 285–299.

Correlation.

1889.1 The Vertebrate Fauna of the Equus Beds. Amer. Naturalist, XXIII, No. 266, February, pp. 160–165.

Elephas primigenius and *Dibelodon shepardi*.

1889.2 The Proboscidia. Amer. Naturalist, XXIII, No. 268, April, pp. 191–211, Pls. ix–xvi, text figs. 1–9.

New genus: *Emmenodon*, p. 194. New species: *Tetrabelodon brevidens*, pp. 195, 201. New subspecies: *Elephas primigenius columbi*, *E. primigenius americanus*, pp. 207, 209. Type figures of *Tetrabelodon brevidens*, *T. euhypodon*, *T. angustidens proavus*, *T. serridens*, and *T. campester*.

1889.3 The Mechanical Causes of the Development of the Hard Parts of the Mammalia. Journ. Morph., III, pp. 137–290, Pls. ix–xvi, text figs 1–93. Philadelphia.

1890.1 Pohlig on Elephas antiquus. Amer. Naturalist, XXIII, 1889, No. 272, August, pp. 712, 713.

1890.2 Synopsis of the Families of Vertebrata. Amer. Naturalist, XXIII, 1889, No. 274, October, pp. 849–877.

Proboscidea, pp. 875, 877.

1890.3 The Silver Lake of Oregon and its Region. Amer. Naturalist, XXIII, 1889, No. 275, November, pp. 970–982, Pls. xl, xli, text fig. 1.

Elephas primigenius equals *Elephas columbi*—W. D. Matthew.

1892.1 Vertebrate Fauna of the Alachua Clays, Florida. Bull. U. S. Geol. Surv., No. 84, 1891, Correlation Papers, Neocene, p. 130.

Mastodon floridanus.

1892.2 The Age of the Staked Plains of Texas. Amer. Naturalist, XXVI, pp. 49, 50.

The association of *Equus* and *Mastodon* of *angustidens* type not observed previously on this continent; the latter ceased with the Loup Fork.

1892.3 A Contribution to the Vertebrate Paleontology of Texas. Proc. Amer. Phil. Soc., XXX, pp. 123–131, text fig. 1. Reprint, "Report on the Palaeontology of the Vertebrata," 3d Ann. Rept. Geol. Surv. Texas, 1891, pp. 251–259.

1892.4 A Contribution to a Knowledge of the Fauna of the Blanco Beds of Texas. Proc. Acad. Nat. Sci. Phila., XLIV, pp. 226–229.

New species: *Mastodon successor*, p. 227.

1892.5 The Fauna of the Blanco Epoch. Amer. Naturalist, XXVI, pp. 1058, 1059.

New species: *Dibelodon præcursor* [name only]. Mentions *D. humboldtii*, *D. tropicus*.

1893.1 A Preliminary Report on the Vertebrate Paleontology of the Llano Estacado. 4th Ann. Rept. Geol. Surv. Texas, for the year 1892, pp. 1–87, Pls. i–xxiii.

New species: *T. serridens cimarronis*, p. 20, and *Mastodon oligobunis*, p. 59. *Tetrabelodon shepardii*; *Mastodon successor* figured as *Dibelodon tropicus*; the specific name *successor* withdrawn by Cope, p. 63; *Dibelodon præcursor*, description, p. 64, and figure.
Abstract, "The Vertebrate Paleontology of the Llano Estacado." Amer. Naturalist, XXVII, 1893, pp. 811, 812.

1893.2 Description of the Lower Jaw of Tetrabelodon shepardii Leidy. Proc. Acad. Nat. Sci. Phila., XLV, pp. 202–204.

Abstract, "Geology and Palæontology, Cenozoic," Amer. Naturalist, XXVII, p. 473, Pl. xii.

1894.1 Observations on the Geology of Adjacent Parts of Oklahoma and Northwest Texas. Proc. Acad. Nat. Sci. Phila., XLVI, pp. 63–68.

Elephas primigenius, from near Hennessy, Okla., p. 68.

1894.2 Extinct Bovidæ, Canidæ and Felidæ from the Pleistocene of the Plains. Journ. Acad. Nat. Sci. Phila., (2), IX, pp. 453–459, Pls. xxi, xxii.

The Mammoth (*E. primigenius*) associated with *Dinobastis* Cope.

Cope, Edward Drinker, and William Diller Matthew

1915.1 See Matthew, William Diller, and Edward Drinker Cope.

Corse, John

1799.1 Observations on the different Species of Asiatic Elephants, and their Mode of Dentition. Phil. Trans. Roy. Soc. London, LXXXIX, Pt. II, Art. XIII, pp. 205–236, Pl. v–xii.

Mooknah and dauntelah varieties of Indian elephant.

Cossmann, Maurice

1896.1 Essais de Paléoconchologie Comparée. Deuxième Livraison, December, pp. 2, 3.

Definition of Plesiotype, Neotype.

1904.1 What is a type in History natural, by Ch. Schuchert. Revue Critique de Paléozoologie, Ann. 8, No. 2, April, pp. 73, 74.

Costa, Oronzio Gabriele

1850.1 Paleontologia del Regno di Napoli. Atti Accad. Pontaniana, V, Pt. I, pp. 233–433, Tav. I–XV. Napoli.

New genus: *Synodontherium*, p. 271, Tav. III.

1864.1 Intorno alle ossa di mammiferi fossili trovate presso Cassino. Rend. Accad. Sci., III, March, pp. 61, 62. Napoli.

1864.2 Relazione intorno agli ossami fossili di Cassino e della Melfa. Rend. Accad. Sci., III, June, pp. 155–161. Napoli.

Cotter, G. de P., and Guy Ellcock Pilgrim

1916.1 See Pilgrim, Guy Ellcock, and G. de P. Cotter.

Cottle, Thomas

1852.1 Fossil Pachydermata in Canada. Ann. Mag. Nat. Hist., (2), X, pp. 395, 396.

Elephas primigenius, Burlington Heights, near head of Lake Ontario.

Coues, Elliott, and Theodore Gill

1877.1 See Gill, Theodore, and Elliott Coues.

Couper, James Hamilton

1843.1 [Letter regarding fossil bones found in Georgia.] Proc. Acad. Nat. Sci. Phila., I, pp. 216, 217.

Mastodon.

1843.2 On Fossil Bones found in Digging the New Brunswick Canal in Georgia. Proc. Geol. Soc. London, IV, pp. 33, 34.

Cox, Percy Zachariah

1900.1 Notes on Somaliland. Journ. Bombay Nat. Hist. Soc., XIII, Pt. I, April 15, pp. 86–99. Madras.

"The African Elephant" on pages 92, 93.

Cragin, Francis Whittemore

1896.1 Preliminary Notice of Three Late Neocene Terranes of Kansas. Colorado Coll. Stud., VI, pp. 53, 54.

Elephas imperator (?).

Croizet, l'Abbé Jean Baptiste, and Antoine Claude Gabriel Jobert

1828.1 Recherches sur les Ossemens Fossiles du Département du Puy-de-Dôme, 224 pp., 9 geologic sections, 46 pls., 1 chart.

New species: *Mastodon arvernensis*, p. 138.

Crook, A. R.

1927.1 Elephas primigenius Boreus Hay at Golconda, Illinois. Trans. Illinois State Acad. Sci., XIX, pp. 288–299, text figs. 1–13.

Culver, Harold Eugene

1927.1 Mastodon Remains in Washington. Science, N.S., LXVI, No. 1718, Dec. 2, pp. 540, 541.

Found about four miles northeast of Blyn, Clallam Co.

Cuvier, Frédéric, and Étienne Geoffroy Saint-Hilaire

1824-1829 Histoire Naturelle des Mammifères, avec des Figures originales, dessinées d'après des Animals vivans etc., III, Livr. LI, LII, 1825, Elephant d'Afrique, 2 pp., 1 pl.; Elephant d'Asie, 9 pp., 2 pls.

New genus: Loxodonte, 'Elephant d'Afrique,' November, 1825, p. 2.
An unsigned review of this work appeared in the Zool. Journ. London, 1827, 1828, III, p. 140, noticing the "dismemberment of the genus *Elephas*, for the purpose of establishing a new one under the name of Loxodonta."

Cuvier, Georges Léopold Chrétien Frédéric Dagobert

1796.1 Mémoire sur les espèces d'Eléphans tant vivantes que Fossiles, lu à la séance publique de l'Institut national le 15 germinal an IV [21 March to 19 April, 1796]. Mag. Encyclop. (known also as Revue encyclopédique), an IV [1796], III (2 an), No. 12, pp. 440–445. First published by Millin, Noel and Warens, afterward by Millin alone.

Use of *mammouth* by natives of Siberia.
[A résumé (unsigned) of the observations of Cuvier and Geoffroy "Sur les espèces d'Eléphans" appears in the Bull. Soc. Philom., Paris, I, an 3 [1795], p. 90.' This is said to be by Cuvier and Geoffroy, due probably to the fact that they worked together and published jointly in many instances. In the case of the present Memoir, it is attributed to Cuvier only. In this résumé [Bull. Soc. Philom., Paris, 1795, I (une première série), an 3 de la République, p. 90')] the word Mammouth is used.

1798.1 Extrait d'un Mémoire sur les Ossemens fossiles de quadrupèdes. Bull. Soc. Philom. Paris, No. 18, Fructidor, an VI [1798], pp 137–139.

Molar in possession of C. Gillet and a "germe" in Nat. Mus. likened to the last lower molar of the rhinoceros, but which later (see Cuvier, 1800.1, p. 73) he regarded as more nearly like the molar of the tapir.

1798.2 Tableau Élémentaire de l'Histoire Naturelle des Animaux, pp. xvi+710, 14 pls.

Elephas indicus, p. 148, *E. capensis*, p. 149.

1799.1 Mémoire sur Les Espèces d'Éléphans Vivantes et Fossiles. Mém. Inst. Nat. Sci. et Arts. Sci., Mathém. et Phys., II, Fructidor, an VII [1799], pp. 1–22, Pls. II–VI. Lu le premier pluvoise an 4. This is sometimes called the Académie des Sciences, II.

In this first revision of the Proboscidea, Cuvier lists two Recent and two Pleistocene species, with figures, as follows:
"Espèces qu'on sait exister.
Elephas capensis, *fronte convexâ, lamellis molarium rhombeidalibus*.
Elephas indicus, *fronte plano-concavâ, lamellis molarium arcuatis undatis*.
Espèces qu'on ne connoît que fossiles.
Elephas mammonteus, *maxilli obtusiore, lamellis molarium tenuibus rectis*.
Elephas americanus, *molaribus multi-cuspidibus, lamellis post detritionem quadri-lobatis*
Cuvier refers to the observations of Pallas on the 'mammouth'; he proposes a new specific name (*E. mammonteus*) for the mammoth and alludes toward the close of his paper to Blumenbach's "Handbuch der Naturgeschichte." Subsequently Cuvier recognized Blumenbach's species *E. primigenius*.

1800.1 Sur les Tapirs fossiles de France. Bull. Soc. Philom. Paris, No. 34, Nivôse, an VIII [1800], pp. 73, 74.

See note under Cuvier, 1798.1.

1806.1 Sur les Éléphans Vivans et Fossiles. Ann. Mus. hist. nat., VIII, pp. 1–58, 93–155, 249–269, Pls. 38–45 (I–VIII). Paris.

Mammont, mammouth, mammontova-kost.
A general and comparative résumé of the height and form of *Elephas africanus*, p. 262, *E. indicus*, p. 263, and *E. primigenius*, p. 264.

1806.2 Sur le Grand Mastodonte. Ann. Mus. hist. nat., VIII, pp. 270–312, Pls. 49–56 (I–VIII). Paris.

First use by Cuvier of the term *Mastodonte*, pp. 270, 272, 294. *Elephant* and *mammouth de l'Ohio*, p. 273.

1806.3 Sur Différentes Dents du Genre des Mastodontes, mais d'espèces moindres que celles de l'Ohio, trouvées en plusieurs lieux des deux continens. Ann. Mus. hist. nat., VIII, pp. 401–424, Pls. 66–69 (I–IV). Paris.

Mastodonte de l'Ohio [=*Mastodon giganteum* Cuv. or *Mastodon americanus* Kerr], p. 412; *Mastodonte à dents étroites* [=*Mastodon angustidens*], p. 412, *Petit mastodonte* [=*Mastodon tapiroides*, *M. minutus*], p. 413; *Mastodons des Cordillères* [=*Mastodon andium*, *M. cordillerarum*], p. 413; *Mastodonte humboldien* [=*Mastodon humboldtii*], p. 413.
Uses the term "tapir gigantesque," p. 417.

1812.1 Recherches sur les Ossemens Fossiles de Quadrupèdes, ou l'on Rétablit les Caractères de Plusieurs Espèces d'Animaux que les Révolutions du Globe Paroissent avoir Détruites, I–IV [1st edition].

Chapters IX, X, XI are identical with Cuvier, 1806.1, 2, 3, but two paragraphs are omitted on pp. 420–424, reprinted as Chapter XII.

1817.1 Le Règne Animal, I, 8vo, Paris, pp. xxxv+540.

Elephas indicus, *E. Africanus*. New genus: *Mastodon*. New species: *Mastodon giganteum* [=*Le grand Mastodonte*], *Mastodon angustidens* [=*Le Mastodonte à dents étroites*], p. 233.

1821-1824 Recherches sur les Ossemens Fossiles. . . . Nouvelle Édition, I–V [2d edition].

1821, I; 1822, II, Pts. I, II; 1822, III; 1823, IV; 1823, V, Pt. I; 1824, V, Pt. II.
There are several new plates of Proboscidea in this edition, and pp. 266–268 of Vol. I appear to be new.
Elephas primigenius, *Mastodonte tapiroïde*, *M. angustidens*, *M. maximus*, *M. Andium*, *M. Humboldtii*, *M. tapiroides*, *M. minutus*, 1824, Pt. II, p. 527.
Tapirs gigantesques, pp. 165, 174, 1822, II, Pt. I.

1825.1 Recherches sur les Ossemens Fossiles. . . . Troisième Édition, I–V.

1834-1836 Recherches sur les Ossemens Fossiles. . . . Quatrième Édition, I–X. Atlas, I, Pls. I–CLXI; II, Pls. CLXII–CCLX, Pls. A–C, E, G, H, J–S.

1834, I–IV; 1835, V–VII; 1836, VIII–X.
Tapir gigantesque, Vol. III, p. 308.

Cuvier, Georges Léopold Chrétien Frédéric Dagobert, and Étienne Geoffroy Saint-Hilaire

1795.1 Mémoire sur une nouvelle division des Mammifères, et sur les principes qui doivent servir de base dans cette sorte de travail, lu à la Société d'Histoire naturelle, le premier floréal [April 15–May 15] de l'an troisième [1795]. Revue Encyclopédique [=Mag. Encyclop. ou Journ. Sci., Lettres, Arts], Ann. I, Tome II, No. VI, pp. 164–190.

Elephantus, p. 189, first used (*fide* Sherborn, 1902, p. 323; Palmer, 1904, p. 943).

Cuvier, Georges Léopold Chrétien Frédéric Dagobert, Charles Léopold Laurillard, and Mercier

1850-1856 Anatomie Comparée: Recueil de Planches de Myologie dessinées par Georges Cuvier, ou Exécutées sous ses yeux par M. Laurillard. Publié sous les Auspices de M. Le Ministre de l'Instruction Publique et sous la Direction de MM. Laurillard . . . et Mercier. 2 vols., 340 pls. Folio. Chez Dusacq, Paris.

Elephant, pp. 270–295.

Cuvier, Georges Léopold Chrétien Frédéric Dagobert, and Bernard Germain Étienne de la Ville Lacépède

1801.1 La Ménagerie du Muséum National d'Histoire naturelle ou Les Animaux Vivants. An X. Folio, Paris.

Figure of male elephant and 12 pages relating to *Elephantus indicus*, under title "L'Éléphant des Indes."
Later in the same volume under the title "L'Éléphant des Indes, Femelle. *Elephantus indicus* Femina," are 6 pages and full plate figure of female in the flesh.

Dall, William Healey

1871.1 [Statement regarding fossil elephant bones occurring with the bones of musk-ox and buffalo near the great bend of the Yukon, Alaska.] Proc. Bost. Soc. Nat. Hist., XIII, p. 136.

1873.1 [Remarks on tusk and lower jaw of Elephas primigenius collected on Elephant Point, Kotzebue Sound, Alaska, by Capt. Smith of Alaska Commercial Company.] Proc. Calif. Acad. Nat. Sci., IV, pp. 293, 294.

1891.1 On the Age of the Peace Creek Beds, Florida. Proc. Acad. Nat. Sci. Phila., XLIII, p. 120.

Mastodon found with bones of manatee, horse, glyptodon, and big turtle.

Dall, William Healey, William Bullock Clark, and George Burbank Shattuck

1904.1 See Clark, William Bullock, George Burbank Shattuck, and William Healey Dall.

Dall, William Healey, and Gilbert Dennison Harris

1892.1 The Neocene of North America. Bull. U. S. Geol. Surv., No. 84, Correl. Papers, 349 pp., 3 pls., 43 text figs.

Map of the known distribution of the Neocene formations in Alaska, Pl. III. See also List of Vertebrata by Leidy, pp. 129, 130.

Dana, James Dwight

1875.1 On Dr. Koch's Evidence with regard to the Contemporaneity of Man and the Mastodon in Missouri. Amer. Journ. Sci., (3), IX, pp. 335–346.

A supplementary article will be found on page 398.

Dart, Raymond A.

1927.1 Mammoths and Man in the Transvaal. Supplement to Nature, No. 3032, Dec. 10, pp. 41–48, text figs. 1–7.

New species: *Archidiskodon transvaalensis, A. sheppardi.*

1929.1 Mammoths and Other Fossil Elephants of the Vaal and Limpopo Watersheds. So. Afr. Journ. Sci., XXVI, December, pp. 698–731, text figs. 1–28.

New species: *Archidiskodon vanalpheni, A. milletti, A. loxodontoides, A. andrewsi, A. hanekomi, A. yorki; Pilgrimia yorki, P. wilmani, P. kuhni; Loxodonta prima, Loxodonta africana* var. *obliqua.* Also treats of *Archidiskodon transvaalensis, A. sheppardi, A. subplanifrons, A. broomi,* and *Loxodonta griqua.* [See Osborn, 1934.925.]

Daubenton, Louis Jean Marie

1764.1 Description de la Partie du Cabinet qui a rapport à l'Histoire Naturelle du Zèbre et de l'Hippopotame. Hist. Nat. Gén. et Particulière, avec la Description du Cabinet du Roi, XII, pp. 69–78, Nos. MLXXXVII–MCXIII.

Davies, William

1874.1 Catalogue of the Pleistocene Vertebrata, from the Neighbourhood of Ilford, Essex, in the Collection of Sir Antonio Brady, Kt., J. P., F.G.S., etc. of Maryland Point, Stratford, Essex. 4to, London, pp. xxvii+75 including Appendix, frontispiece, and section with key.

Mammoth.

Dawkins, William Boyd

1903.1 On the Discovery of an Ossiferous Cavern of Pliocene Age at Doveholes, Buxton (Derbyshire). Quart. Journ. Geol. Soc. London, LIX, pp. 105–132, Pls. VIII–XII, text figs. 1–10.

Mastodon arvernensis, Elephas meridionalis.

Dawson, Charles, Arthur Smith Woodward, and Grafton Elliot Smith

1913.1 On the Discovery of a Palæolithic Human Skull and Mandible in a Flintbearing Gravel overlying the Wealden (Hastings Beds) at Piltdown, Fletching (Sussex). Quart. Journ. Geol. Soc. London, LXIX, March, pp. 117–151, Pls. XV–XXI, text figs. 1–10.

Stegodon sp. [=*Archidiskodon planifrons*], Pl. XXI.
See Supplementary Note in Quart. Journ. Geol. Soc. London, LXX, 1914, April, pp. 82–92, Pls. XIV, XV, text figs. 1–3.
Stegodon mentioned on page 92.
See Freudenberg, Wilhelm, 1915.1, for review of 1913 paper.

Dawson, George Mercer

1894.1 Notes on the Occurrence of Mammoth Remains in the Yukon District of Canada and Alaska. Quart. Journ. Geol. Soc. London, L, pp. 1–9.

De Blainville, Henri Marie Ducrotay

See Blainville, Henri Marie Ducrotay de.

Defay, ————

1783.1 La nature considérée dans plusieurs de ses opérations, ou mémoires et observations sur diverses parties de l'histoire naturelle; avec la minéralogie de l'Orléanois. 8vo, Paris, Cuchet éditeur. [See Gaudry, 1862–1867, p. 153.]

The present author has not seen this publication; a copy is in the Royal Society library of England.
Gaudry states that Defay mentioned three molars in his description of 1783 and that the third molar cited is that described by Cuvier under the name *Mastodon tapiroides.*

DeKay, James Ellsworth

1842.1 Natural History of New York. Part I, Zoology: Zoology of New York, or the New York Fauna. 4to, New York, Boston, and Albany, pp. xiii+146, 33 pls.

Elephas americanus, p. 101, Pl. XXXII.

DeKay, James Ellsworth, William Cooper, and J. A. Smith

1831.1 See Cooper, William, J. A. Smith, and James Ellsworth DeKay.

De Lorenzo, Giuseppe

1904.1 Geologia e Geografia fisica dell'Italia meridionale. Bari Laterza. (Original not available.)

1926.1 L'Elephas antiquus di Pignataro Interamna in Valle del Liri. Atti Reale Accad. Naz. Lincei, Rend., Cl. Sci. fis., mat. e nat., (6ª), IV, 2° sem., Fasc. 5–6, pp. 185–188, text fig. Rome.

First description of specimen named by Osborn (1931) *Palæoloxodon antiquus italicus.*

De Lorenzo, Giuseppe, and Geremia D'Erasmo

1927.1 L'Elephas antiquus nell'Italia Meridionale. Atti Accad. Sci., (2ª), XVII, No. 11, pp. 1–104, Tav. I–X, text figs. 1–21. Napoli.

Second description of specimen named by Osborn (1931) *Palæoloxodon* [=*Hesperoloxodon*] *antiquus italicus.*

1930.1 Nuove Osservazioni su l'Elephas antiquus dell'Italia Meridionale. Atti Accad. Sci., (2ª), XVIII, No. 5, 15 pp., 12 text figs. Napoli.

1931.1 Ancora su l'Elephas antiquus di Pignataro Interamna. Rend. Accad. Sci., (4), I, pp. 16–19. Napoli.

1932.1 L'Uomo Paleolitico e l'Elephas antiquus nell'Italia Meridionale. Atti Accad. Sci., (2ª), XIX, No. 5, 106 pp., 9 Tav., 42 text figs. (reprint). Napoli.

Excellent map and photographic reproductions of the region near Pignataro Interamna, where the type of *Palæoloxodon* [=*Hesperoloxodon*] *antiquus italicus* was found.

Depéret, Charles

1885.1 Description Géologique du Bassin Tertiaire du Roussillon et Description des Vertébrés Fossiles du Terrain Pliocene du Roussillon. Ann. Sci. géol., XVII, pp. 1–272, Pls. I–V, map. Paris.

1887.1 Recherches sur la Succession des Faunes de Vertébrés Miocènes de la Vallée du Rhone. Arch. Mus. hist. nat. Lyon, IV, pp. 45–307, 25 pls.

Treats at length of *Mastodon* and *Dinotherium.*

1890.1 Les Animaux Pliocènes du Roussillon. Mém. Soc. géol. France, No. 3, pp. 1–194, Pls. I–XIX, text figs. 1–4, table.

In a list of the fauna of the Pliocene of Roussillon *Mastodon arvernensis* and *M. borsoni* are given. See especially pp. 61–67, Pl. V, of Mém. No. 3 (Tome I, Pl. XIX, of Memoirs).

1892.1 Note sur la Classification et le Parallélisme du Système Miocène. Bull. Soc. géol. France, (3), XX, pp. CXLV–CLVI.

Depéret, Charles—Continued

1893.1 Sur la Classification et le Parallélisme du Système Miocène. Bull. Soc. géol. France, (3), XXI, pp. 170–266.

1894.1 Note sur la Succession Stratigraphique des Faunes de Mammifères Pliocènes d'Europe et du Plateau Central en Particulier. Bull. Soc. géol. France, (3), XXI, pp. 524–540.

1897.1 Découverte du Mastodon Angustidens dans l'Étage Cartennien de Kabylie. Bull. Soc. géol. France, (3), XXV, pp. 518–521, Pl. xix.

New subspecies: *Mastodon angustidens* Cuv. mut. asc. *pygmæus*.

1905.1 L'Évolution des Mammifères tertiaires; importance des migrations. [Éocène.] Compt. Rend. Acad. Sci., CXLI, séance Nov. 6, pp. 702–705. Paris.

1906.1 L'Évolution des Mammifères tertiaires; importance des migrations. [Oligocène.] Compt. Rend. Acad. Sci., CXLII, séance Mar. 12, pp. 618–620. Paris.

1906.2 L'Évolution des Mammifères tertiaires; importance des migrations. Époque miocène. Compt. Rend. Acad. Sci., CXLIII, seance Dec. 24, pp. 1120–1123. Paris.

1907.1 Sur l'Âge des couches à Palæomastodon du Fayoum. (2e Note). Bull. Soc. géol. France, (4), VII, pp. 455, 456.

Belongs in the Sannoisien sup. or at extreme base of the Stampien.

1907.2 Les Transformations du Monde animal. 12mo, Paris, 360 pp.

1908.1 The Evolution of Tertiary Mammals, and the Importance of their Migrations. (Trans. First Paper. Eocene Epoch.) Amer. Nat., XLII, No. 494, February, pp. 109–114.

1908.2 The Evolution of Tertiary Mammals, and the Importance of their Migrations. (Trans. Second Paper. Oligocene Epoch.) Amer. Nat., XLII, No. 495, March, pp. 166–170.

1908.3 The Evolution of Tertiary Mammals, and the Importance of their Migrations. (Trans. Third Paper. Miocene Epoch.) Amer. Nat., XLII, No. 497, pp. 303–307.

Depéret, Charles, Lucien Mayet, and Frédéric Roman

1923.1 Les Éléphants Pliocènes. Première Partie, pp. 1–87, text figs. 1–13, Elephas planifrons Falconer . . . par Lucien Mayet et Frédéric Roman; Deuxième Partie, pp. 89–213, Monographie des Éléphants Pliocènes de l'Europe et de l'Afrique du Nord . . . par Charles Depéret et Lucien Mayet. Ann. Univ. Lyon, Nouv. Sér. I.—Sciences, Médicine. Fasc. 43, pp. vii–ix, 1–213, Pls. i–xi, 47 text figs.

D'Erasmo, Geremia

1928.1 Il Tetrabelodon (Trilophodon) angustidens Cuvier sp. della pietra leccese. Rend. Accad. Sci., (3), XXXIV, Ann. 68, Fasc. 9–12, pp. 220–235, figs. 1, 2. Napoli.

D'Erasmo, Geremia, and Giuseppe De Lorenzo

See De Lorenzo, Giuseppe, and Geremia D'Erasmo.

Desmarest, Anselme Gaetan

1818.1 Mastodonte (Mastodon), Cuv. Nouveau Dictionnaire d'Histoire Naturelle, XIX, pp. 439–447.

Mastodon minor, p. 446; *Mastodon Humboldtii*, p. 447.

1820–1822 Mammalogie ou Description des Espèces de Mammifères. Première Partie (1820, pp. viii+276); Seconde Partie (1822, pp. viii+277–530; Supplement, pp. 531–555).

Mastodon cordillerarum, new species, 1822, p. 385; *M. humboldtii*, *M. minus*, and *M. tapiroides*, p. 386.

Desnoyers, Jules Pierre François Stanislas

1829.1 Observations sur un ensemble de dépôts marins plus récens que les terrains tertiaires du Bassin de la Seine et pouvant constituer une formation géologique distincte. Ann. Sci. nat., XVI, pp. 402–491. Paris.

Mastodon maximus.

Desor, Pierre Jean Édouard

1837.1 Notice sur le Dinotherium giganteum, quadrupède mammifère antédiluvien d'une taille colossale. Paris, 12 pp., 4 text figs.

Dietrich, Wolfgang O.

1912.1 Elephas primigenius Fraasi, eine schwäbische Mammutrasse. Jahresh. Ver. Naturk. Württemb., LXVIII, pp. 42–106, Taf. i, ii, text figs. 1–26.

1913.1 Zur Stammesgeschichte des afrikanischen Elefanten. Zeitschr. indukt. Abstamm. Vererbungsl., X, pp. 49–73, text figs. 1–7. Berlin.

1916.1 Elephas antiquus Recki n.f. aus dem Diluvium Deutsch-Ostafrikas. Arch. Biontol., IV, Heft I, pp. 1–80, Taf. i–viii, text figs. 1–6. Berlin.

1918.1 Über eine neue Mastodon-Rekonstruktion (Mastodon angustidens Cuv.). Naturw. Wochenschr., N.F., XVII, No. 26, pp. 369–372, text figs. 1, 2.

1921.1 Über den "horizontalen Zahnwechsel" bei Mastodon und Elephas. Centralb. Min. Geol. Pal., No. 19, October, pp. 595–602, text figs. 1–4.

1924.1 Elephas antiquus Recki n.f. aus dem Diluvium Deutsch-Ostafrikas. Wiss. Ergebn. Oldoway-Expedition, II Teil, pp. 1–38, Taf. i–vi.

1926.1 Zur Altersbestimmung der Pithecanthropus-Schichten. Sitz.-Ber. Ges. naturf. Freunde Berlin. Jahrg. 1924, pp. 134–139.

Dixey, Frank

1927.1 The Tertiary and Post-Tertiary Lacustrine Sediments of the Nyasan Rift-Valley. Quart. Journ. Geol. Soc. London, LXXXIII, Pt. III, pp. 432–447, Pls. xxx–xxxiii.

Appendix I by Arthur Tindell Hopwood: "On Some Mammalian Remains from Lake Nyasa," pp. 442–444.
Appendix II by Matthew Connolly: "Report on a small Collection of Fossil Freshwater Mollusca from Lake Nyasa," pp. 444, 445.
Discussion, pp. 445–447.

D'Orbigny, Alcide

1842.1 Voyage dans l'Amérique Méridionale . . . . III, Pt. IV, Palèontologie, pp. 1–188, Pls. i–xxii.

Mastodon andium.

Dorlhac, J.

1855.1 Notice Géologique sur le Cratère de Coupet et sur son Gisement de Gemmes et d'Ossements Fossiles. Ann. Soc. Agric. Puy, XIX, for 1854, pp. 497–517.

New species: *Ananeus macroplus* Aymard, first publication of the name, p. 507.

Dubois, Eugen

1904.1 On an Equivalent of the Cromer Forest-Bed in Netherland. Proc. Koninkl. Akad. Wetenschap. Amsterdam, VII, pp. 214–222, text figs. 1 and 2.

1908.1 Das Geologische Alter der Kendeng-Oder Trinil-Fauna. Tijdschr. Nederl. Aardr. Genoots Amsterdam, (2), XXVB, No. 6, pp. 1235–1270, Taf. xxxix.

New species: *Stegodon Ganesa* var. *javanicus*, *Elephas hysudrindicus*.

Duméril, André Marie Constant

See notes under Blainville, Henri Marie Ducrotay de (1837.1, 1837.2).

Dupont, Édouard François

1873.1 L'Homme pendant les Ages de la Pierre dans les Environs de Dinant-sur-Meuse. Les Temps Préhistoriques en Belgique. Bruxelles, 250 pp., 4 pls., 41 text figs., synoptic table.

Mounted skeleton (Pl. II) of the Mammoth [*Mammonteus primigenius*] in the Musée Royale d'Histoire Naturelle, Brussels.

Du Toit, Alexander Logie

1907.1 Geological Survey of the Eastern Portion of Griqualand West. 11th Ann. Rept. Geol. Comm. for 1906, Cape Town, pp. 87–176, text figs.

Eales, Nellie Barbara

1925.1 External Characters, Skin, and Temporal Gland of a Foetal African Elephant. Proc. Zool. Soc. London, Pt. II, (published July 21), pp. 445–456, text figs. 1–5.

1926–1929 The Anatomy of a Foetal African Elephant, Elephas africanus (Loxodonta africana). Parts I [the Head], II [the Body Muscles], III [Contents of the Thorax and Abdomen and the Skeleton]. Trans. Roy. Soc. Edinb., LIV, pp. 491–551, Pls. i–xii, 1926; LV, pp. 609–642, Pls. i–v, 1928; LVI, pp. 293–346, Pls. i–vi, 1929.

Eastman, Charles Rochester

1904.1 Earliest Notice of American Proboscidea. Science, N.S. XX, No. 521, Dec. 23, p. 890.

Eck, H.

1892.1 Mastodon aff. longirostris Kaup von Lahr. Neues Jahrb. Min. I, p. 151.

Éhik, Julius, and Tibor Szalay

1930.1 Prodinotherium Hungaricum N.G., N.Sp. Appendix by T. Szalay "On the Geological Occurrence of Prodinotherium Hungaricum Éhik." Geol. Hungarica, Ser. Palaeont., Fasc. 6, Jan. 25, pp. 1–24, Pls. I–IV, text fig. Budapest.

New genus and species: *Prodinotherium hungaricum*.

Eichwald, Eduardus

1827.1 Naturhistorische Skizze von Lithauen, Volhynien und Podolien. (Original not available.)

1831.1 Zoologia Specialis, III, 404 pp., I Tav.

New species: *Mastodon intermedius*, p.361. *Tapirus proavus* described on p. 353.

1832.1 Fossile Wirbelthiere in Russisch Polen. Neues Jahab. Min., pp. 354–356.

Mastodon ohioticum mentioned on p. 355.

1835.1 De Pecorum et Pachydermorum reliquiis fossilibus in Lithuania, Volhynia et Podolia Repertis. Nova Acta Acad. Leop. Carol., XVII, pp. 677–760, Pls. LI–LXIV.

New species: *Elephas odontotyrannus, Dinotherium proavum* et *uralense, Mastodon podolicus* [=*Deinotherium podolicum*]. Supplementary description of *Mastodon intermedius*.

1837.1 Sein Dinotherium proavum. Neues Jahrb. Min., pp. 43, 44.

Apparently the first time *Dinotherium proavum* appeared in this form. Refers his *Mastodon podolicum* to *Dinotherium*, p. 44.

1838.1 Ueber Die Dinotherien und einige ihnen verwandte Thiere Russlands. Bull. Acad. Imp. Sci., St. Pétersb., IV, No. 17, pp. 258–266.

1850.1 Palaeont. Rossii. St. Petersburg.

Sherborn (1922.1, p. 124) gives this reference for *Elephas affinis*, p. 179; this work, however, is not available to the present author.

1853.1 Lethaea Rossica ou Paléontologie de la Russie. Dernière Période, III, 8vo, Stuttgart, 533 pp.; Atlas, Période Moderne, III, 13 pls.

Dernière Période, Proboscidea, pp, 345–355, especially p. 350 (*Elephas affinis*); Atlas, III, Pl. XI, fig. 36, "Dent molaire d'un Mammouth (Elephas affinis)."

Emmons, Ebenezer

1858.1 Report of the North-Carolina Geological Survey. Agriculture of the Eastern Counties; together with Descriptions of the Fossils of the Marl Beds. 8vo, Raleigh, pp. xvi+314, 256 text figs.

Proboscideans: *Mastodon giganteus* [=type of *Gomphotherium? emmonsi* Hay, 1930=*Ocalientinus emmonsi*], pp. 198–200, fig. 23.

1860.1 Manual of Geology: Designed for the use of Colleges and Academies. 8vo, New York, pp. xi+297, 218 text figs.

Mastodon giganteus molar from marl beds of North Carolina (see note under Emmons, 1858.1) refigured on p. 218, fig. 186.

Emmons, Ebenezer, and A. J. Prime

1845.1 See Prime, A. J., and Ebenezer Emmons.

Etheridge, Jr., Robert, and Robert L. Jack

1892.1 See Jack, Robert L., and Robert Etheridge, Jr.

Evans, George Henry

1910.1 Elephants and Their Diseases. A Treatise on Elephants. Rangoon Superintendent Government Printing, Burma, pp. viii+343, 19 pls. and frontispiece.

Fabiani, Ramiro

1928.1 Cenni sulle raccolte di Mammiferi quaternari del Museo Geologico della R. Università di Palermo e sui risultati di nuovi assaggi esplorativi. Boll. Assoc. Min. Siciliana, An. IV, N. 5, pp. 25–34, text figs. 1–4.

Elephas (antiquus) mnaidriensis and *E. (ant.) melitensis*.

Falconer, Hugh

1845.1 Description of some Fossil Remains of Dinotherium, Giraffe, and other Mammalia from the Gulf of Cambay, Western Coast of India. Quart. Journ. Geol. Soc. London, I, pp. 356–372, Pl. XIV, text fig.

New species: *Dinotherium indicum*.

1857.1 On the Species of Mastodon and Elephant occurring in the fossil state in Great Britain. Part I. Mastodon. Quart. Journ. Geol. Soc. London, XIII, pp. 307–360, Pls. XI, XII.

Trilophodon and *Tetralophodon* defined as subgenera of *Mastodon*. New genera: *Euelephas* [invalid], *Pentalophodon* [name only]. New species: *Elephas giganteus* Aymard (in Falconer, p. 321). *M. (Triloph.) Pandionis* [name only]; *M. (Triloph.) Pyrenaicus* [Lartet MS. name only]; *E. (Eueleph.) Armeniacus* [name only]; *E. (Eueleph.) Columbi*; *E. (Eueleph.) antiquus;* mentioned in the Synoptic Table (opp. p. 319).

1859.1 Descriptive Catalogue of the Fossil Remains of Vertebrata from the Sewalik Hills, the Nerbudda, Perim Island, etc., in the Museum of the Asiatic Society of Bengal. 8vo, Calcutta, 261 pp. (Assisted by H. Walker.)

1863.1 On the American Fossil Elephant of the Regions Bordering the Gulf of Mexico. (E. Columbi, Falc.); with General Observations on the Living and Extinct Species. Nat. Hist. Rev., III, pp. 43–114, Pls. I, II. London and Edinburgh.

Treats the species *E. jacksoni, E. texianus, E. columbi, E. Armeniacus*, and the genus *Pentalophodon*.

1865.1 On the Species of Mastodon and Elephant occurring in the Fossil State in Great Britain. Part II. Elephant. Quart. Journ. Geol. Soc. London, XXI, pp. 253–332.

Pentalophodon defined; [see Falconer, 1857.1, for name only].

1867.1 Description of the Plates of the Fauna Antiqua Sivalensis, from Notes and Memoranda. (Ed. Charles Murchison.) Hardwicke, 8vo, London, pp. 1–64, 1–136.

Pages 1–64 consist of a reprint of the Letterpress of Falconer, 1846; pp. 1–136, of a "Description of the Plates in the Fauna Antiqua Sivalensis."

1868.1 Palæontological Memoirs and Notes of the Late Hugh Falconer. . . . With a Biological Sketch of the Author. (Ed. Charles Murchison.) 8vo, London, I, pp. lvi+590, 34 pls., 16 text figs.; II, pp. xiii+675, 38 pls., 9 text figs.

New genera: *Antoletherium*, Vol. I, p. 416, *Rhynchotherium*, Vol. II, pp. 74, 75. New species: *Dinotherium Perimense* [name only].

1867.1 See Busk, George.

Falconer, Hugh, and Proby Thomas Cautley

1846.1 Fauna Antiqua Sivalensis, being the Fossil Zoology of the Sewalik Hills in the North of India. Pt. I, Proboscidea, 8vo, London, 64 pp. Folio, London, Illustrations, Pts. I–IX, 107 pls.. 1846 [1845]–1849.

Part I. Proboscidea.	(Elephas: 12 lithogr. Taf.) 1845.
II.	(Elephas: lithogr. Taf. 13-22, incl. XIII A, B.) 1847.
III.	(Elephas und 1 Fig. Mastodon: lithogr. Taf.: 12 A, B, C, D, 14 A, B, 18 A, 19 A, 20 A, 23, 24, 24 A.) 1847.
IV.	(Elephas und Mastodon: lithogr. Taf.: 25, 25 A, 26–29, 29 A, B, 30–33.) 1847.
V.	(Mastodon etc. lithogr. Taf.: 34–45). 1847.
VI.	(Lithogr. Taf.: 46–56). 1847.

(Compiled from British Catalogue and Carus and Engelmann.)

The only part of the Letterpress which ever appeared was published in 1846 under the title, "Fauna Antiqua Sivalensis," being the Fossil Zoology of the Sewalik Hills in the North of India," Part I, Proboscidea, 1846 [64 pp.]. This Part was reprinted in 1867 as the first sixty-four pages of "Description of the Plates of the Fauna Antiqua Sivalensis from Notes and Memoranda by Hugh Falconer. . . . Compiled and edited by Charles Murchison." Consequently the proper bibliographic references are as given above under 1846.1 and 1867.1.

New genera: *Trilophodon* (section name): *Tetralophodon* (section name); *Stegodon; Loxodon* [invalid]; *Elasmodon* [invalid]. New species: *Elephas Hysudricus* (Pl. I); *E. planifrons* (Pl. II); *E. insignis* (Pl. II); *E. ganesa* (Pl. III); *E. namadicus*, p. 45, *E. bombifrons*, p. 46, *E. cliftii*, p. 47, *E. antiquus* (Pl. XII.D), *Mastodon perimensis*, type figure, *Elephas indicus* (Dauntela var.), *E. indicus* (Mukna var.).

Felix, Johannes

1912.1 Das Mammuth von Borna. Veröff. Städt. Mus. Völkerkunde, 8vo, Leipzig, Heft IV, 52 pp., 8 Taf., 9 text figs., frontispiece.

Felix, Johannes, and Hans Lenk

1891.1 Uebersicht über die geologischen Verhältnisse des mexicanischen Staates Puebla. Palaeontogr., XXXVII, March, pp. 117–139, Taf. XXX. (Theil III of Beiträge zur Geologie und Palæontologie der Republik Mexico von Dr. J. Felix and Dr. H. Lenk.)

Filhol, Henri

1891.1 Études sur les Mammifères Fossiles de Sansan. Ann. Sci. géol., XXI, pp. 1–314, Pls. I–XLVI. Paris.

Mastodon augustidens, M. turicensis.

Fischer, Joanne Baptista

1829–1830 Synopsis Mammalium. 8vo, Stuttgardtiae, Sumtibus J. G. Cottae, pp. xlii+527.

In 1830 Fischer published the "Addenda, Emendanda et Index ad Synopsis Mammalium," pp. 529–752.
Elephas and *Mastodon* treated (1829) on pages xxx, 404–408.

Fischer de Waldheim, Gotthelf

1808.1 Programme d'Invit. Séance. Pub. Soc. Imp. Nat. Moscou, pp. 19, 20, September. (Original not available.)

New genus and species: *Harpagmotherium canadense* (or *Harpagonotherium*, see Sherborn, 1924.1, p. 1022).

1814.1 Zoognosia. Tabulis Synopticis Illustrata. 8vo, Mosquae, III, pp. xxiv+694.

New genus: *Mastotherium*, p. 337. New species: *Mastotherium megalodon, M. leptodon, M. microdon, M. hyodon, M. Humboldtii*, pp. 337–341.

1829.1 Notice sur Quelques Animaux Fossiles de la Russie. Nouv. Mém. Soc. Imp. Nat. Moscou, I, pp. 283–299, Pl. xvii.

New species: *Elephas mammonteus, E. paniscus, E. periboletes, E. pygmaeus, E. campylotes.*

1829.2 Fossiles. Notice sur Le Mammont. Bull. Soc. Imp. Nat. Moscou, Première Année, No. 9, pp. 267–278.

New species: *Elephas Kamenskii.*

1830–1837 Oryctographie du Gouvernement de Moscou. Pts. I–III. Folio, Moscou, pp. v+202+xvii, 53 Tab.

Mammont, Mammontova Kost, p. 111, *Elephas mammonteus*,Tab. i.

1834.1 Bibliographia Palaeonthologica Animalium Systematica. Editio altera, aucta, jussu Societatis Caesareae Natura Scrutatorum Impressa. 8vo, Mosquae. Typis Universitatis Caesareae, pp. viii+414.

Invaluable bibliography of the first period (cf. p. 2 of the present Memoir) of palæontology (1760–1834), pages 1–128, followed by an equally invaluable subject bibliography of fossil vertebrates and invertebrates, pages 128–372, also by a complete authors' and subject index, pages 373–414.

Fitzinger, Leopold Joseph Franz Johann

1827.1 Nachricht über die zu Wien in der Sandgrube am Rennwege kürzlich aufgefundenen fossilen Zähne u. Knochen eines urweltlichen Thieres (Mastodon angustidens), in zoolog. u. geolog. Hinsicht betrachtet. 8vo, Wien. (Original not available.)

Flerov, Constantine C.

1931.1 A Trunk of Mammoth (Elephas primigenius Blum.) found in the Kolyma District (Siberia). Bull. Acad. Sci. U.S.S.R., pp. 863–870, Pls. i, ii, text figs. 1–4.

First discovery of the tip of a mammoth's trunk—it is illustrated in text figs. 1–3.

Flower, William Henry, and Richard Lydekker

1891.1 An Introduction to the Study of Mammals Living and Extinct. 8vo, Adam and Charles Black, London, pp. xvi+763, 357 text figs.

Proboscidea, pp. 418–436.

Foetterle, Franz von

1853.1 Bericht über die geologische Aufnahme des südlichen Mähren. Jahrb. geol. Reichsanst., Jahrg. IV, Heft I, pp. 33–57. Wien.

Dinotherium giganteum, p. 40.

1857.1 [Dinotherium-Reste von Herrn Jos. Eggerth.] Jahrb. geol. Reichsanst., Jahrg. VIII, Sitzung, Jan. 27, pp. 167, 168. Wien.

1865.1 Kieferstück eines Mastodon angustidens von Eibiswald. Jahrb. geol. Reichsanst., Jahrg. XV, Sitzung, Nov. 14, Heft IV, p. 234. Wien.

Fortis, Giovanni Battista detto Alberto

1786.1 Delle Ossa d'Elefanti e d'altre Curiosità Naturali de Monti de Romagnano nel Veronese. Vicenza, 85 pp., 1 pl.

Foster, John Wells

1839.1 Head of Mastodon Giganteum. Amer. Journ. Sci., (1), XXXVI, pp. 189–191, text figs. 1, 2.

Refers to fossil elephant found at Jackson Co., Ohio, by Mr. C. Briggs and himself.

1857.1 On the Geological Position of the Deposits in which occur the Remains of the Fossil Elephant of North America. Proc. Amer. Assn. Adv. Sci., 10th Meeting, Albany, New York, August, 1856, pp. 148–169.

See especially p. 157 (cross-section of elephant bed near Zanesville, Ohio); also p. 159 (lacustrine deposits at type locality of *Elephas jacksoni*).

1872.1 A New species of Fossil Elephant, Elephas Mississippiensis. Nature, VI, Sept. 26, p. 443.

Proc. Amer. Assoc. Adv. Sci., August, 1872, p. 259: "Elephas Indianapolis A New Species of Fossil Elephant." Professor Calvin (1911, p. 213) states in a footnote that after reading the paper, Foster proposed to change the name to *Elephas mississippiensis*.

Fourtau, René, and Armand Ruffer

1918.1 Contribution a l'Étude des Vertébrés Miocènes de l'Égypte. Ministry of Finance, Egypt, Surv. Dept., pp. xi+99; Appendix, Studies in Palæopathology by Armand Ruffer, pp. 101–109, Pl. i, text figs. 1–66.

New species: *Mastodon angustidens* Cuvier var. *libycus*; *M. Spencer*i. In the second edition of 1920 there is no change in the description or figures of either of these species.

Fraas, Eberhard

1907.1 Pleistocäne Fauna aus den Diamantseifen von Südafrika. Zeitschr. deutsch. geol. Ges., LIX, pp. 232–243, Taf. viii. Berlin.

Mastodon sp. (Waldeck Plant), Taf. viii, fig. 1, fragment of molar.

Fraas, Oscar Friedrich von

1870.1 Die Fauna von Steinheim. Jahresh. Ver. naturk. Württemb., XXVI, Hefte II, III, pp. 145–306, Taf. iv–xiii.

Mastodon arvernensis, p. 184, Taf. v, fig. 1. [Made the type of *Mastodon steinheimensis* by Klähn in 1922, changed by him in 1931 to *Mastodon angustidens steinheimensis*.]

Frade, Fernando

1924.1 Notes de Mammalogie Africaine. Bull. Soc. Portugaise Sci. nat., IX, Fasc. 3, pp. 127–135, text figs. 1–6. Lisbon.

New subspecies: *Elephas africanus mozambicus*

1925.1 Os Elefantes actuais e os seus antepassados. A propósito de "Maputo" e de "Ipana." Colecção Natura (Soc. Sci. nat. Portucalensis), Lisboa, pp. 1–48, text figs. 1–10.

1928.1 Títulos e trabalhos cientificos (Curriculum vitae), pp. 15, 16. Lisboa.

New subspecies: *Loxodonta africana angolensis*, from region of Cunene, living in the Zoological Gardens of Lisbon.

1931.1 Sur l'Existence en Afrique de Deux Espèces d'Éléphants. Bull. Soc. Portugaise Sci. nat., XI, No. 9, October, pp. 135–138. Lisbon.

1932.1 Elefantes africanos de 'Estepa' e de 'Floresta.' Asoc. Española Prog. Cien. Congr. Decimotercero, Lisboa, (IV), V, Pt. II, pp. 25–28, text figs. 1, 2. Madrid.

1933.1 La Mandibule des Éléphants actuels. Compt. Rend. Assn. Anatom., April 10–12, pp. 1–6, text figs. 1, 2.

Mandibles of *Loxodonta cyclotis*; *L. africana* figured.

1933.2 Eléphants du Mozambique. Bull. Soc. Portugaise Sci. nat., XI, No. 29, December, pp. 307–318, Pls. xviii, xix. Lisbon.

1933.3 Eléphants d'Angola. Bull. Soc. Portugaise Sci. nat., XI, No. 30, December, pp. 319–333, Pls. xx, xxi. Lisbon.

Freudenberg, Wilhelm

1909.1 Das Diluvialprofil von Jockgrim in der Pfalz. Ber. oberrheim. geol. Ver., XLII. (Original not seen by the present author.)

1913.1 Elephas primigenius fraasi Dietrich und die schwäbische Hochterrasse. Centralb. Min. Geol. Pal., Nr. 15, Aug. 1, pp. 475–480; Nr. 20, Oct. 15, pp. 646–652. Stuttgart.

1915.1 [Review of Charles Dawson and Arthur Smith Woodward on the discovery of Piltdown man (Eoanthropus dawsoni) and associated mammalian remains.] Neues Jahrb. Min., I (1915), pp. 416–420, 2 text figs.

"*Elephas* cf. *planifrons* (wohlnicht *Stegodon*)," p. 420.

1922.1 Die Säugetierfauna des Pliocäns und Postpliocäns von Mexiko. II teil: Mastodonten und Elefanten. Geol. u. Pal. Abh., XIV (XVIII), Heft III, pp. 103–176, Taf. i (ix) ix (xvii), text figs. 1–28. Jena.

New subspecies: *Mastodon digobunus* var. *antiquissima*, *M. digobunus* var. *Felicis*, *M. digobunus* var. *intermedia*, *M. digobunus* var. *pompeiana*; *Elephas columbi* var. *Felicis*, *E. columbi* var. *silvestris*, *E. columbi* var. *Falconeri*, *E. columbi* var. *imperator*.

1926.1 Die altquartären Proboscidier im Oberrheingebiet. Palaeont. Zeitschr., VIII, Heft I, pp. 68, 69.

1927.1 [Discussion of O. Schmidtgen's paper "Über Elephas trogontherii Pohl."] Palaeont. Zeitschr., VIII, Heft I, pp. 68–69

[See Schmidtgen, 1926.1, pp. 62–68.]

Friant, M.

1931.1 Un cas de persistance de l'incisive moyenne supérieure des Proboscidiens primitifs chez l'Eléphant d'Afrique (Loxodonta africana Blum.). Compt. Rend. Assn. Anatom., 26th Réunion, pp. 191–197, text figs. 1–3.

Frick, Childs

1921.1 Extinct Vertebrate Faunas of the Badlands of Bautista Creek and San Timoteo Cañon, Southern California. Bull. Dept. Geol. Univ. Calif., XII, No. 5, Dec. 28, pp. 277–424, Pls. xliii–l, text figs. 1–165.

New subspecies: *Trilophodon (Tetrabelodon) shepardi edensis* [=*Rhynchotherium shepardi edense*].

1926.1 Tooth Sequence in Certain Trilophodont Tetrabelodont Mastodons and Trilophodon (Serridentinus) pojoaquensis, New Species. Bull. Amer. Mus. Nat. Hist., LVI, Art. II (issued April 9), pp. 122–176, text figs. 1–27. Addenda, pp. 177, 178.

New species: *Trilophodon (Serridentinus) pojoaquensis*, *T. (Ser.) leidii*, *?Rhynchotherium (Dibelodon) edensis*.

1926.2 Prehistoric Evidence. Nat. Hist., Amer. Mus., XXVI, No. 5, September–October, pp. 440–448, text figs. 4.

Fig. 1 shows the lignite mines of Val d'Arno, Italy; the coal workings of Monte Bamboli, Italy; the badlands of Santa Fé, New Mexico.

1930.1 Alaska's Frozen Fauna. Nat. Hist., Amer. Mus., XXX, No. 1, January–February, pp. 71–80, frontispiece and 14 figs.

1933.1 New Remains of Trilophodont-Tetrabelodont Mastodons. Bull. Amer. Mus. Nat. Hist., LIX, Art. IX, Mar. 2, pp. 505–652, 46 text figs.

Fritsch, Karl Wilhelm Georg von

1885.1 Das Pliocän im Thalgebiete der zahmen Gera in Thüringen. Jahrb. geol. Landesanst. Berlin, pp. 389–437, Taf. xxiii–xxv, map.

Mastodon arvernensis, p. 399.

Fuchs, Theodor

1879.1 Ueber neue Vorkommnisse fossiler Säugethiere von Jeni Saghra in Rumelien und von Ajnácskö in Ungarn, etc. Verh. geol. Reichsanst., No. 3, pp. 49–59. Wien.

Mastodon arvernensis and *M. borsoni*.

Furlong, Eustace L.

1925.1 Notes on the Occurrence of Mammalian Remains in the Pleistocene of Mexico, with a Description of a New Species Capromeryx Mexicana. Bull. Dept. Geol. Univ. Calif., XV, No. 5 (issued Jan. 30), pp. 137–152, text figs. 1–11.

Proboscidean remains particularly abundant at Tequixquiac and Zumpango and in the area between these two towns. Possibly the last of the Pleistocene fauna to become extinct, and may be the site of their latest survival on the continent. Also found in the quarry of El Tajo in deposits overlying the fissures.

Furlong, Eustace L., and Chester Stock

1928.1 See Stock, Chester, and Eustace L. Furlong.

Gastaldi, Bartolomeo

1861 [1858] Cenni sui Vertebrati Fossili del Piemonte. Mem. Accad. Sci. Torino, (2), XIX, pp. 19–84, Tav. i–x.

Mastodon arvernensis, *M. borsoni*, *Elephas meridionalis*, *E. antiquus*, *E. primigenius*.

Gaudry, Albert

1860.1 Résultats des nouvelles fouilles exécutées sous les auspices de l'Académie à Pikermi (Grèce); Lettre à M. le Secrétaire perpétuel et Lettre à M. d'Archiac. Compt. Rend. Acad. Sci., LI, pp. 802–804. Paris.

1862–1867 Animaux Fossiles et Géologie de l'Attique. 4to, Paris, 474 pp., Atlas, 75 pls., map.

Type figure of *Mastodon pentelici* [=*Trilophodon (Choerolophodon) pentelicus*]. *Mastodon turicensis* and *Dinotherium* treated.

1876.1 Matériaux pour l'Histoire des Temps Quaternaires. 4to, Paris, 62 pp., 11 pls., 6 text figs.

Elephas primigenius (race à lames écartées), p. 49, Pl. ix.

1878.1 Les Enchainements du Monde Animal. 8vo, Paris, 293 pp., 312 text figs.

1888.1 Les Ancêtres de Nos Animaux, dans les Temps Géologiques. 12mo, Paris, pp. xv+296.

1889.1 Sur les Mastodontes trouvés à Tournan, dans le Gers, par M. Marty. Compt. Rend. Acad. Sci., CVIII, pp. 1293, 1294. Paris.

Mastodon angustidens.

1891.1 Quelques Remarques sur les Mastodontes a propos de l'Animal du Cherichira. Mém. Soc. géol. France, Paléontologie, II, Fasc. I, Mém. No. 8, pp. 1–6, Pls. i, ii.

Mastodon angustidens, *M. turicensis*.

1893.1 L'Éléphant de Durfort. Volume Commémoratif du centenaire de la Fondation du Muséum d'Histoire Naturelle. 4to, Paris, 25 pp., 1 pl.

Elephas [=*Archidiskodon*] *meridionalis* of Durfort.

Gaudry, Albert, and Édouard Lartet

1856.1 Résultats des recherches paléontologiques entreprises dans l'Attique sous les auspices de l'Académie. Compt. Rend. Acad. Sci., XLIII, pp. 271–274. Paris.

New species: *Mastodon pentelicus*.

Gay, Claudio

1847.1 Historia Fisica y Politica de Chile. Zoologia, I, 496 pp. . . . Mamiferos, (pp. 19–182); Aves by DeMurs (pp. 183–494).

Mastodon andium, pp. 137, 138.

Geinitz, Hanns Bruno

1846.1 Grundriss der Versteinerungskunde. R.8vo, Dresden and Leipzig, pp. x+817, 26 Taf.

Proboscidea, pp. 31–40.

Geoffroy Saint-Hilaire, Étienne

1837.1 Encore cet écrit sur le Sivatherium, considéré sous le point de vue de ses révélations contestées relativement à la Philosophie zoologique. Compt. Rend. Acad. Sci., IV, No. 4, pp. 113–122, text figs. 1–4. Paris.

New genus: *Dicyclotherium*.

Geoffroy Saint-Hilaire, Étienne, and Frédéric Cuvier

1824-1829 See Cuvier, Frédéric, and Étienne Geoffroy Saint-Hilaire.

Geoffroy Saint-Hilaire, Étienne, and Georges L. C. F. D. Cuvier

1795.1 See Cuvier, Georges Léopold Chrétien Frédéric Dagobert, and Étienne Geoffroy Saint-Hilaire.

Geoffroy Saint-Hilaire, Isidore

1837.1 See note under Blainville, Henri Marie Ducrotay de.

Gerstaecker, Carl Eduard Adolph, and Julius Victor Carus

1868.1 See Carus, Julius Victor, and Carl Eduard Adolph Gerstaecker.

Gervais, François Louis Paul

1848-1852 Zoologie et Paléontologie Francaises . . . Premier ed., I, pp. viii+271; II Explanation of Plates; III, Atlas, 80 pls.

Mastodon brevirostris, first described by Gervais and de Serres in 1846 as *Mastodon brevirostre*.

1855.1 Recherches sur les mammifères fossiles de l'Amérique méridionale. "Animaux nouveaux ou rares recueillis pendant l'expédition dans les parties centrales de l'Amérique du Sud, de Rio de Janeiro à Lima, et de Lima au Para; exécutée . . . pendant 1843 à 1847 sous la direction du Comte Francis de Castelnau," Pt. VII, Tome I, pp. 1–64, Pls. iv–xiii.

1859.1 Zoologie et Paléontologie Francaises . . . Deuxième ed., pp. viii+544; Atlas, 84 pls.

Mastodon brevirostris, type figures same as in edition of 1848–1852.

1867-1876 Zoologie et Paléontologie Générales. Ser. 1 (1867–1869), pp. vii+263, 50 pls., 41 text figs.; Ser. 2 (1876). 4to, Paris.

Dinotherium, p. 152. Proboscidea not treated in Series 2.
The first edition (1864–1869) not available.

Gervais, François Louis Paul, and Pierre Marcel Toussaint de Serres

1846.1 Sur les Mammifères dont on a trouvé les restes fossiles dans la caverne de Lunel-Viel et dans les sables de Montpellier. Ann. Sci. nat., (3), V, pp. 266–271. Paris.

New species: *Mastodon brevirostre*.
An extract of this paper appeared in the Compt. Rend. Acad. Sci., Paris, 1846, XXII, p. 295, but without name of *Mastodon brevirostre*.

Gez, Juan W.

1915.1 Generalidades sobre paleontologia argentina: El Mastodon platensis-Amegh. de Corrientes. Corrientes, 2ª edición. (*Fide* Cabrera, 1929.1, p. 142; original not available.)

New species: *Mastodon pirayuiensis*, p. 35.

Gibbes, Robert Wilson

1850.1 Remarks on the Northern Elephas of Prof. Agassiz. Proc. Amer. Assoc. Adv. Sci., 3d Meeting, Charleston, S. C., p. 69.

1850.2 Remarks on Mastodon angustidens. Proc. Amer. Assoc. Adv. Sci., 3d Meeting, Charleston, S. C., pp. 69, 70.

Gidley, James Williams

1903.1 The Fresh-Water Tertiary of Northwestern Texas. American Museum Expeditions of 1899–1901. Bull. Amer. Mus. Nat. Hist., XIX. Art. XXVI, pp. 617–635, Pls. lii–lviii, text figs. 1–4, map.

1913.1 Preliminary Report on a Recently Discovered Pleistocene Cave Deposit near Cumberland, Maryland. Proc. U. S. Nat. Mus., XLVI, pp. 93–102, text figs. 1–8.

Proboscidea not found.

1922.1 Preliminary Report on Fossil Vertebrates of the San Pedro Valley, Arizona, with Descriptions of New Species of Rodentia and Lagomorpha. U. S. Geol. Surv., Profess. Paper 131—E, Dec. 26, pp. 119–131, Pls. xxxiv, xxxv.

Preliminary faunal list, p. 120.

1926.1 Fossil Proboscidea and Edentata of the San Pedro Valley, Arizona. U. S. Geol. Surv., Profess. Paper 140—B, January, pp. 83–95, Pls. xxxii–xliv.

New species: *Stegomastodon arizonae* description and figure. [Name first occurs in Osborn, 1924.634, p. 4.] *Anancus bensonensis* [= *Cordillerion bensonensis*].

1929.1 Ancient Man in Florida: Future Investigations. Bull. Geol. Soc. Amer., XL, June 30, pp. 491–501, Pls. xiv, xv.

A revision of his conclusions as expressed in 1926 in a paper prepared by F. B. Loomis and himself, after a restudy of beds 2 and 3 of Sellards, especially at Melbourne, Vero, and other places in Florida, pp. 498, 499. "It seems probable that the remains of the mammoth, mastodon, horse, camel, tapir, and other animals found by earlier expeditions above the contact plane had been worked out of bed number 2 by the agencies—human or animal, or both—that formed the basin-shaped depressions before bed number 3 had been laid down."

Gidley, James Williams, and Frederic Brewster Loomis

1926.1 Fossil Man in Florida. Amer. Journ. Sci., XII, pp. 261, 262.

Giebel, Christof Gottfried Andreas

1845.1 Bericht über die von Dr. Giebel in den Diluvialablangerungen des Seveckenberges den Quedlinburg aufgefundenen fossilen knochen. Isis, [XXXVIII], Heft XII, pp. 905–910.

Elephas.

1846.1 Knochen-Lager bei Quedlinburg. Neues Jahrb. Min., pp. 459, 460.

New species: *Elephas minimus*, p. 459; *E. minimus* Nesti [in Falconer, 1846.1, p. 13, not found in Nesti, 1808].

1847.1 Die Säugethiere der Vorwelt. Fauna der Vorwelt, I, Abth. I, pp. xi+467. Leipzig.

See especially *E. minimus* Giebel and *E. antiquitatis* Krüger, p. 211.

1855.1 Die Säugethiere in zoologischer, anatomischer und palaeontologischer Beziehung umfassend dargestellt. 8vo, Leipzig, pp. xii+1108.

Proboscidea, pp. 122, 123 (*Dinotherium*), 155–176.

Gilbert, Grove Karl

1871.1 Remains of a Mastodon. Proc. Lyc. Nat. Hist. New York, pp. 220, 221.

Geological position of mastodon found at St. Johns, Auglaize Co., Ohio.

Gill, Theodore Nicholas

1872.1 On the Characteristics of the Primary Groups of the Class of Mammals. Proc. Amer. Assoc. Adv. Sci., 20th Meeting, Indianapolis, pp. 284–306.

Proboscidea, p. 301; also see Amer. Nat., V, pp. 526–533.

1872.2 Arrangement of the Families of Mammals. With Analytical Tables. Smithson. Misc. Coll., XI (1874), No. 230, pp. vi+98.

Proboscidea, pp. 13, 89, 90.

Gill, Theodore, and Elliott Coues

1877.1 Material for a Bibliography of North American Mammals. Rept. U. S. Geol. Surv. Terrs. Hayden, XI, Appendix B, pp. 951–1081.

Gilmore, Charles Whitney

1908.1 Smithsonian Exploration in Alaska in 1907 in Search of Pleistocene Fossil Vertebrates. Second Expedition. Smithson. Misc. Coll., LI (1910), No. 1807, pp. 3–38, Pls. i–xiii, text figs. 1–4.

Lists the Alaskan fauna known at that time, p. 38.

Girard, Charles

1852.1 On the Classification of Mammalia. Proc. Amer. Assoc. Adv. Sci., for the year 1851, 6th Meeting, Albany, N. Y., pp. 319–335, 2 diagrams.

Elephantidæ, Mastodontidæ, Dinotheridæ, pp. 326, 328.

Glocker, Ernst Friedrich von

1852.1 Mineralogische und geognostische Notizen aus Mähren. Jahrb. geol. Reichsanst., Jahrg. III, Heft III, pp. 130–132. Wien.

Dinotherium, p. 132.

Gloger, Constantin Wilhelm Lambert

1841.1 Gemeinnütziges Hand- und Hilfsbuch Naturgeschichte der Thiere, pp. xxxiv+495. (Original not available.) The British Catalogue states that this was issued in 6 Hefte, of which 1–5, pp. 1–400, appeared in 1841.

Gamphotherium angustidens, p. 191. [*Gamphotherium* is regarded as a misspelling of *Gomphotherium* Burmeister, 1837.]

Gmelin, Johann Fridrich, Carolus Linnæus, and Robert Kerr

1792.1 See Kerr, Robert, Carolus Linnæus, and Johann Fridrich Gmelin.

Godman, John Davidson

1824.1 Description of the Os Hyoides of the Mastodon. Journ. Acad. Nat. Sci. Phila., IV, Pt. I, pp. 67–72, Pl. II.

1826–1828 American Natural History, I (1826), II (1826), III (1828). 8vo, Philadelphia.

Mastodon giganteus, II, pp. 202–255; *Elephas primogenius* [= *primigenius*], pp. 255–265.

1830.1 Description of a New Genus and New Species of Extinct Mammiferous Quadruped. Trans. Amer. Phil. Soc., N.S., III, pp. 178–185, Pls. xvii, xviii.

New genus: Tetracaulodon. New species: *Tetracaulodon Mastodontoideum*.

Goldfuss, Georg August

1821.1 Osteologische Beiträge zur Kenntniss Verschiedener Säugthiere der Vorwelt. Nova Acta Acad. Leop. Carol., X, Pt. II, pp. 455–502, Tab. xxxix, xla, xlb, xlia, xlib, xliia, xliib, xliv, xlv. Bonn.

New species: *Elephas priscus*. Trouessart cites *priscus* on page 705 of his Catalogue of 1898–1899, but the word does not seem to appear in Goldfuss' description; it is figured, however, Tab. xliv.

1823.1 Osteologische Beiträge zur Kenntniss Verschiedener Säugthiere der Vorwelt. Nova Acta Acad. Leop. Carol., XI, pp. 451–490, Tab. liv–lvii.

Elephas priscus, see page 489.

Goodwin, George C.

1926.1 The Most Respectable Animal in the World. Asia, January, pp. 38, 39, 75, 76, 1 fig.

The first living elephant brought to America, 1795.

Göppert, Heinrich Robert, and Hermann von Meyer

1848.1 See Meyer, Hermann von, and Heinrich Robert Göppert.

Graells, D. Mariano de la Paz

1897.1 Fauna Mastodológica Ibérica. Mem. Real. Acad. Cien. Exactas, Fis. nat., Madrid, XVII, 806 pp., 22 Lám., 2 maps.

New species: *Elephas platyrhynchus*, p. 569; *Mastodon auvilicus*, p. 573.

Granger, Walter, and William Diller Matthew

1923.1 See Matthew, William Diller, and Walter Granger.

Granger, Walter, and Henry Fairfield Osborn

1931.1 See Osborn, Henry Fairfield, 1931.847.

1932.1 See Osborn, Henry Fairfield, 1932.886.

Grant, [R.] E.

1842.1 On the Structure and History of the Mastodontoid Animals of North America. Proc. Geol. Soc. London, III, Pt. II, No. 90, pp. 770, 771.

New species: *Tetracaulodon Hayni*, *T. Bucklandi*. Reviews *T. Jacksi*.

Gray, Asa

1846.1 Food of the Mastodon. Proc. Bost. Soc. Nat. Hist., II, pp. 92, 93.
Reprinted in Amer. Journ. Sci., (2), III, p. 436.

Gray, John Edward

1821.1 On the Natural Arrangement of Vertebrose Animals. London Medical Repository, XV, No. 88, April 1, pp. 296–310.
New families: Elephantidæ, p. 305; Mastodonadæ, p. 306.

1843.1 List of the Specimens of Mammalia in the Collection of the British Museum. 12mo, pp. xxviii+216.
E. indicus, Dauntelah and Mooknah varieties, p. 183; *Loxodonta africana*, p. 184.

1869.1 Catalogue of Carnivorous, Pachydermatous and Edentate Mammalia in the British Museum. 8vo, pp. vii+398, 47 text figs.
Elephas indicus, p. 358; *Loxodonta africana*, p. 359.

Gregory, William King

1903.1 Adaptive Significance of the Shortening of the Elephant's Skull. Bull. Amer. Mus. Nat. Hist., XIX, pp. 387–394, Pl. xxiii, text figs. 1–4.

1909.1 Review of Gaudry's Memoir on Pyrotherium. Science, N.S., XXX, pp. 180–182.
Question whether *Pyrotherium* is related to the Proboscidea.

1910.1 The Orders of Mammals. Bull. Amer. Mus. Nat. Hist., XXVII, pp. 1–524, text figs. 1–32.
Proboscidea especially treated on pp. 366–369.

1920.1 Studies in Comparative Myology and Osteology; No. IV. A Review of the Evolution of the Lacrymal Bone of Vertebrates with Special Reference to that of Mammals. Bull. Amer. Mus. Nat. Hist., XLII, Art. II, pp. 95–263, Pl. xvii, text figs. 1–196.
Morphology of the lacrymal region of the Proboscidea, pp. 180–183; relationships of the Proboscidea, pp. 244, 245.

1934.1 On the Significance of the Supra-symphysial Depression and Groove in the Shovel-tusked Mastodonts. Journ. Mamm., XV, No. 1, February, pp. 4–12, text figs. 1–8.

Grewingk, Constantin Caspar Andreas

1881.1 Ueber Fossile Säugethiere von Maragha in Persien. Verh. geol. Reichsanst., No. 15, p. 296. Wien.

Guettard, Jean Étienne

1756 [1752] Suite du Mémoire dans lequel on compare le Canada à la Suisse, par rapport à ses minéraux. Seconde partie. Hist. Acad. Roy. Sci. avec Mém. Math. Phys. Paris, for the year 1752, pp. 323–360, Pls. i–iv and map (Pls. 9–12 of Mém.).
"Une grande molaire de l'*Ohio*," Pls. iii, iv.

Gunn, John

1867.1 [Teeth of Elephants from Norfolk.] Note in Geol. Mag., IV, No. XXXIX, pp. 421, 422.
New genus: *Leptodon*.

1883.1 Does Elephas primigenius occur in the Norfolk Forest Bed? Geol. Mag., Dec. II, N.S., X, pp. 456–460.
New species: *Leptodon minor*, *L. giganteus*, *Elephas Gunnii* Lartet (in Gunn).

1884.1 The Mammoth in the Forest Bed. Geol. Mag., Dec. III, N.S., I, pp. 47, 48.

1891.1 Memorials of John Gunn . . . Being Some Account of the Cromer Forest Bed and its Fossil Mammalia, and of the associated strata in the cliffs of Norfolk and Suffolk: From the MS. Notes of the late John Gunn. With a Memoir of the Author. (Edited by Horace B. Woodward with the assistance of E. T. Newton.) 4to, Norwich, pp. vii+5 (unnumbered)+120, 11 text figs. (Pls. i–v on Proboscidea; Pls. i–vii on Cervidæ).
New subspecies: *E. giganteus intermedius* [same as *Leptodon giganteus* Gunn and *E. Gunnii* Lartet (in Gunn, 1883)].

Hall, James

1871.1 Notes and Observations on the Cohoes Mastodon. 21st Ann. Rept. Regents Univ. New York, pp. 99–148, Pls. iii–vii.

Harlan, Richard

1825.1 Fauna Americana: being a description of the Mammiferous Animals inhabiting North America. 8vo, published by Anthony Finley, Philadelphia, pp. x+318.
Elephas primogenius, *Mastodon giganteum*, *M. angustidens*.

1834.1 Critical Notices of Various Organic Remains hitherto Discovered in North America. Trans. Geol. Soc. Penn., I, Pt. 1, pp. 46–112.
M. giganteum or *maximus* of Cuvier.

1835.1 Critical Notices of Various Organic Remains hitherto Discovered in North America. In "Medical and Physical Researches," pp. 253–313, 2 pls.
Same as in 1834 publication.

1835.2 Observations on the Fossil Elephant Teeth of North America. In "Medical and Physical Researches," pp. 359–361, 1 pl.

1842.1 Notice of two New Fossil Mammals from Brunswick Canal, Georgia; with observations on some of the fossil quadrupeds of the United States. Amer. Journ. Sci., (1), XLIII, July 6, pp. 141–144, Pl. iii.
Genus *Tetracaulodon* without foundation. "*Mastodon longirostris*"—Miocene of Maryland.

1842.2 [A List of fossil bones from Brunswick Canal, Georgia, presented to the Phila. Acad. Nat. Sci. by J. Hamilton Couper, Esq., Darien, Ga.] Proc. Acad. Nat. Sci. Phila., I, Oct. 7, pp. 189, 190.
Important as giving the fauna found accompanying the type of *E. columbi*.

1843.1 Remarks on Mr. Owen's Letter to the Editors on Dr. Harlan's New Fossil Mammalia. Amer. Journ. Sci., (1), XLV, pp. 208–211.
Tetracaulodon only a variety of *Mastodon*.

Harris, Gilbert Dennison, and William Healey Dall

1892.1 See Dall, William Healey, and Gilbert Dennison Harris.

Hartnagel, Chris Andrew, and Sherman C. Bishop

1923.1 The Mastodons, Mammoths and Other Pleistocene Mammals of New York State. Bull. N. Y. State Mus., Nos. 241, 242, January–February, 1921, pp. 1–110, Pls. i–xxv.
While the title-page bears date of 1922, Hay, 1929, p. 210, states that this Bulletin was issued May, 1923.

Haug, Émile

1907-1911 Traité de Géologie, I (1907), II (1908–1911). 8vo, Paris, 2024 pp., 125 pls., 485 text figs.
Dinotherium in Africa, II, p. 1727, Pl. cxxx; list of vertebrates given by E. Brumpt, a member of the expedition of Vicomte du Bourg de Bozas.

Haughton, Sidney Henry

1922.1 A Note on Some Fossils from the Vaal River Gravels. Trans. Geol. Soc. S. Africa, XXIV, pp. 11–16, Pl. i.
New species: *Loxodonta griqua* [=*Metarchidiskodon griqua*, see Osborn, 1934.925, pp. 2, 6–8, 12].

1932.1 On Some South African Fossil Proboscidea. Trans. Roy. Soc. So. Africa, XXI, Pt. I, pp. 1–18, Pls. i–iv, text figs. 1–8.
New species: *Pilgrimia archidiskodontoides*, *P. subantiqua*, *Loxodonta africana obliqua*.

Hauser, Franz

1856.1 Dinotherium aus dem Leitha-Kalk am Neusiedler-See. Jahrb. geol. Reichsanst., VII, p. 612. Wien.

Hay, Oliver Perry

1899.1 A Census of the Fossil Vertebrata of North America. Science, N.S., X, No. 254, pp. 681–684.
Out of 436 genera and 1182 species of mammals, 2 genera and 18 species are listed as proboscideans (p. 682).

1902.1 Bibliography and Catalogue of the Fossil Vertebrata of North America. Bull. U. S. Geol. Surv., No. 179, 868 pp.

1909.1 The Geological and Geographical Distribution of Some Pleistocene Mammals. Science, N.S., XXX, pp. 890–893.
Elephas columbi, *E. primigenius*. Elephants and mastodonts continued to inhabit the Mississippi Valley long after the glaciers had receded from the region and therefore during at least a part, if not the whole, of the Postglacial stage of the Pleistocene.

1912.1 The Recognition of Pleistocene Faunas. Smithson. Misc. Coll., LIX (1913), No. 20, pp. 1–16, text figs. 1–10.
Distribution of *M. americanum*, *E. primigenius*, *E. columbi* in the United States.

1912.2 The Pleistocene Period and its Vertebrata. Dept. Geol. Nat. Resources, Indiana, 36th Ann. Rept. for 1911, pp. 538–784, Pls. i–xxxi, text figs. 1–76.
M. americanum, with list of localities where Indiana Mastodons have been found; *Elephas primigenius* and *E. columbi*, with localities where elephants have been found in Indiana.

Hay, Oliver Perry—Continued

1914.1 The Pleistocene Mammals of Iowa. Iowa Geol. Surv., Ann. Rept. for 1912, XXIII, 662 pp., 75 pls., 142 text figs.

New genus: *Rhabdobunus*. New species: *Mammut progenium*.

1917.1 Descriptions of Some Fossil Vertebrates found in Texas. Bull. Univ. Texas, No. LXXI, Dec. 20, 1916, pp. 1–24, Pls. I–IV. (Not issued until after Jan. 1, 1917.)

New species: *Gomphotherium gratum, G. elegans*.

1917.2 Vertebrata mostly from Stratum No. 3, at Vero, Florida, together with Descriptions of New Species. 9th Ann. Rept. Florida State Geol. Surv., pp. 43–68, Pl. III, text figs. 1–6.

Gives *M. americanus* and *E. columbi* as occurring in these Pleistocene deposits.

1917.3 Description of a New Species of Mastodon, Gomphotherium elegans, from the Pleistocene of Kansas. Proc. U. S. Nat. Mus., LIII, No. 2198, June, pp. 219–221, Pl. XXVI.

Supplementary description of *Gomphotherium elegans*.

1918.1 Fossils. In "The Quarterly Geology of Southeastern Wisconsin," by William C. Alden. U. S. Geol. Surv. Profess. Paper 106, pp. 346, 347.

Mammut americanum, Elephas primigenius.

1919.1 Pleistocene Geology and Vertebrate Paleontology of the Atlantic Coast Plain. Publ. Carnegie Instn. Wash. Year Book No. 17 (1918), pp. 311, 312.

"*Elephas imperator* and *Gomphotherium* appear to have died out before or during the Kansan glacial stage. Lissie and Beaumont formations of Texas belong . . . approximately to the time of the first interglacial stage, as they contain remains of . . . *E. imperator*."

1919.2 On Some Proboscideans of the State of New York. Science, N.S., XLIX, No. 1268, April 18, pp. 377–379.

1919.3 Description of Some Mammalian and Fish Remains from Florida, of probably Pleistocene Age. Proc. U. S. Nat. Mus., LVI, No. 2291, pp. 103–112, Pls. XXVI–XXVIII.

Left ramus of lower jaw determined by Leidy as belonging to *Elephas columbi*, regarded as *E. imperator* by Hay, p. 103, Pl. XXVI, fig. 1.

1919.4 On the Relative Ages of Some Pleistocene Deposits. Amer. Journ. Sci., (4), XLVII, pp. 361–375.

Occurrence of *Elephas primigenius, E. columbi, E. imperator*, and *Gomphotherium*.

1920.1 Descriptions of Some Pleistocene Vertebrates found in the United States. Proc. U. S. Nat. Mus., LVIII, No. 2328, pp. 83–146, Pls. III–XI, 4 text figs.

Materials from five collections: Whitesburg, Tenn., *E. primigenius;* Cavetown, Md., *E. columbi?;* Alton, Ill., *M. americanum;* from near Afton, Okla., *M. americanum, E. imperator, E. columbi;* from Bulverde cave, Texas, *E. primigenius*.

1922.1 Further Observations on Some Extinct Elephants. Proc. Biol. Soc. Wash., Sept. 30, XXXV, pp. 97–102.

New species: *Elephas rooseveltl*.

1923.1 The Pleistocene of North America and Its Vertebrated Animals from the States East of the Mississippi River and from the Canadian Provinces East of Longitude 95°. Publ. Carnegie Instn. Wash., No. 322, pp. VIII+499, 25 text figs., 41 maps.

Proboscidea: Pleistocene mastodons (pp. 45–146); *Elephas columbi* (pp. 147–161); *Elephas imperator* (pp. 162–165); elephants of undetermined species (pp. 166–182); Pleistocene geology of North America and its relation to its fossil vertebrates (pp. 281–406); see maps 5–10, 12, 13, 15, 16, and especially maps 11 and 14.

1923.2 Characteristics of Sundry Fossil Veretbrates. Pan-Amer. Geol., XXXIX, pp. 101–120, Pls. VII–IX, text figs. 4, 5.

New species: *Anancus brazosius*.
Transfer of *Gomphotherium elegans* to *Anancus elegans*, p. 113.

1924.1 The Pleistocene of the Middle Region of North America and Its Vertebrated Animals. Publ. Carnegie Instn. Wash., No. 322A (copies first issued Oct. 15), pp. VII+385, 5 text figs., 29 maps.

Proboscidea, pp. 10–121, maps 2–14. Refers Fort Worth molar, l.M^4, to *Anancus gratus*, p. 13.

1925.1 A Further and Detailed Description of the Type of Elephas rooseveltl Hay and Descriptions of Three Referred Specimens. Proc. U. S. Nat. Mus., LXVI (1926), No. 2571, Art. XXXIV, pp. 1–5, Pls. I, II, text fig.

1925.2 On Remains of Mastodons found in Texas, Anancus brazosius and Gomphotherium cimarronis. Proc. U. S. Nat. Mus., LXVI (1926), No. 2572, Art. XXXV, pp. 1–15, Pls. I–IV, text figs. 1–9.

1925.3 Extinct Proboscideans of Mexico. Pan-Amer. Geol., XLIV, pp. 21–37, Pls. III, IV.

Review of Freudenberg's paper (1922.1). Regards *Mastodon oligobunis Felicis* Freudenberg as belonging to *Anancus*, namely, *Anancus felicis* (see p. 27).

1925.4 Review of Dr. Günther Schlesinger's paper on Mastodons. Journ. Wash. Acad. Sci., XV, No. 16, Oct. 4, pp. 381–387.

1926.1 Two New Pleistocene Mastodons. Journ. Wash. Acad. Sci., XVI, No. 2, Jan. 19, pp. 35–41, Pls. I, II, figs. 1–4.

New species: *Mammut francisi, M. oregonense*.

1926.2 Description of Remains of an Elephant found at Port Williams, Washington. Journ. Wash. Acad. Sci., XVI, No. 6, March 19, pp. 154–159, figs. 1, 2.

New species: *Elephas cellei*.

1926.3 A Collection of Pleistocene Vertebrates from Southwestern Texas. Proc. U. S. Nat. Mus., LXVIII (1927), No. 2625, Art. XXIV, pp. 1–18, Pls. I–VIII, 2 text figs.

New species: *Anancus orarius* and *A. deflorratus*. Redetermines the Fort Worth l.M^4 as *Anancus orarius* rather than *A. gratum* as referred by him in 1911 [1924], p. 13.

1927.1 The Pleistocene of the Western Region of North America and Its Vertebrated Animals. Publ. Carnegie Instn. Wash., No. 322B (copies first issued July 21), pp. V+346, 9 pls., 19 text figs., 21 maps.

Proboscidea, pp. 10–53; Pleistocene geology of western region of North America and remains of vertebrates occurring in it, pp. 129–269; see maps 2–8. Note especially Santa Rosa Island fauna, pp. 42, 164, 194, 195.

1929, 1930 Second Bibliography and Catalogue of the Fossil Vertebrata of North America. Publ. Carnegie Instn. Washington, No. 390. Vols. I (1929, August, pp. VIII+916); II (1930, Jan. 27, pp. XIV+1074).

Proboscidea, Vol. II, pp. 620–653. New subfamily: Mammutinæ, p. 623. New species: *Gomphotherium(?) emmonsi* [=*Ocalientinus emmonsi*], p. 639; *Gomphotherium serpentinirale* [=nomen nudum], p. 639.

Hay, Oliver Perry, and Harold James Cook

1928.1 Preliminary Descriptions of Fossil Mammals Recently Discovered in Oklahoma, Texas and New Mexico. Proc. Colo. Mus. Nat. Hist., VIII, No. 2, Pt. I, Feb. 2, p. 33.

New species: *Elephas haroldcooki*.

1930.1 Fossil Vertebrates Collected Near, or in Association With, Human Artifacts at Localities near Colorado, Texas; Frederick, Oklahoma; and Folsom, New Mexico. Proc. Colo Mus. Nat. Hist., IX, No. 2, Oct. 20, pp. 4–40, Pls. I–XIV.

Supplementary description with figure of *Elephas haroldcooki* Hay, 1928. New species: *Gomphotherium priestleyi*.

Hayasaka, Ichiro

1929.1 A Note on Some Recent Discoveries of Fossil Mammals in Japan. Proc. Fourth Pacific Sci. Cong., Java, III, pp. 405–411.

Elephas trogontherii Pohlig from Province of Shinano, p. 409.

1933.1 On the Stegodon Newly Found in Taiwan. Taiwan Chigaku Kiji [Rec. Geol. Surv. Formosa], IV, April, pp. 25–28. (Published in Japanese.)

Brief résumé in English. Fragment of a right lower jaw bone with [illegible] molar found near Sinshiku, Taiwan. Provisionally referred to *Stegodon sinensis* Owen.

Hayden, Ferdinand Vandeveer

1872.1 Preliminary Report of the United States Geological Survey of Montana and Portions of Adjacent Territories, being a Fifth Annual Report of Progress. Government Printing Office, 8vo, Washington, D. C., Pt. I, 203 pp., 64 text figs., 5 maps.

Elephas primigenius, p. 43.

Hayes, Seth

1894-1895 The Shaw Mastodon, an Examination and Description of Mastodon and accompanying Mammalian Remains found near Cincinnati, June, 1894. Journ. Cincinnati Soc. Nat. Hist., XVII, pp. 217–226, Pls. XI, XII, map.

Hays, Isaac

1834.1 Descriptions of the Specimens of Inferior Maxillary Bones of Mastodons in the Cabinet of the American Philosophical Society, with Remarks on the Genus Tetracaulodon (Godman), etc. Trans. Amer. Phil. Soc., N.S., IV, pp. 317–339, Pls. xx–xxix.

New species: *Mastodon Borsoni, M. Curieri, M. jeffersonii, Tetracaulodon Collinsii, T. Godmani.*

1842.1 [Remarks on collection of fossil bones, chiefly Mastodon, exhibited by Mr. Koch.] Proc. Amer. Phil. Soc., II, pp. 102, 103, 105, 106.

Tetracaulodon.

1842.2 [Review of paper by Prof. Owen on Koch's collection of mammalian remains, especially of the genus Tetracaulodon.] Proc. Amer. Phil. Soc., II, [Aug. 19], pp. 183, 184.

1843.1 [On the Mastodontoid animals in the collection of Mr. Koch.] Proc. Amer. Phil. Soc., II, [Oct. 6], pp. 264–266.

1843.2 [Motion of Dr. Hays to have casts made of the tooth of Mastodon Chapmani.] Proc. Amer. Phil. Soc., II, [Oct. 6], p. 270.

1843.3 On the Family Proboscidea, their general character and relations, their mode of dentition, and geological distribution. Proc. Amer. Phil. Soc., III, [Oct. 6], pp. 44–48.

1846.1 [Remarks in regard to recently discovered mastodons in New York and New Jersey.] Proc. Amer. Phil. Soc., IV, [Nov. 11], p. 269.

Hays, Isaac, and William E. Horner

1842.1 See Horner, William E., and Isaac Hays.

Heck, Ludwig

1899.1 Lebende Bilder aus dem Reiche der Tiere, Berlin. (Original not available.)

Type figure of *Elephas africanus cyclotis* (*fide* Lydekker, 1907.2, p. 782).

Heilprin, Angelo

1887.1 The Geographical and Geological Distribution of Animals. International Scientific Series, LVII, 8vo, New York, pp. xii+435.

Pages 365–367 on elephants.

Heller, Edmund, and Theodore Roosevelt

1914.1 See Roosevelt, Theodore, and Edmund Heller.

Hensel, Reinhold Friedrich

1863.1 Bestimmung über die Reste einiger Säugethierarten von Pikermi in der Münchener Sammlung. Monatsber. Akad. Wiss. Berlin, for the year 1862, pp. 560–569, 1 Taf.

Dinotherium, p. 564.

Herz, Otto

1902.1 Berichte des Leiters der von der kaiserlichen Akademie der Wissenschaften zur Ausgrabung eines Mammuthkadavers an die Kolyma-Beresowka Ausgesandten Expedition. 4to, St. Pétersbourg, 38 pp., 10 Taf.

Hescheler, Karl von

1931.1 Ein ungewöhnliches Fundstück vom Mammut aus dem Kanton Aargau. Eclogæ geol. Helvetiæ, XXIV, No. 2, pp. 260–266, text figs. 1–6.

Hesse, Curtis J.

1935.1 An Immature Mastodon from the Ogallala Pliocene. Journ. Mamm., XVI, No. 1, February, pp. 61–63, text figs. 1, 2.

Heurn, F. C. van

1929.1 De Olifanten van Sumatra. Published with the aid of Konink. Vereenig. Kolon. Inst., Het Oostkust van Sumatra Inst. Reprint, 43 pp., 17 text figs.

Higley, William Kerr

1886.1 A Paper on Elephas primigenius. Bull. Chicago Acad. Sci., I, No. 10, pp. 123–127, plate.

Hilber, Vincenz

1908.1 Das Alter der steirischen Braunkohlen. Mitt. Geol. Ges. Wien, I, pp. 71–76.

Hilzheimer, Max

1913.1 Handbuch der Biologie der Wirbeltiere. R.8vo, Stuggart, pp. viii+754, 599 text figs.

Hingenau, Otto von

1852.1 Uebersicht der geologischen Verhältnisse von Mähren und österr. Schlesien. 8vo, Wien, pp. viii+82.

Dinotherium, p. 25.

1858 [1848] Dinotherium giganteum von Keltschau in Mähren. Haidinger's Ber. Mitt. Freunden Naturw. Wien, III, No. 5, pp. 379, 380.

Hippolyte-Boussac, P.

1907.1 L'Éléphant dans l'ancienne Égypte. Le Naturaliste, 21e Année, 2e Série, pp. 274–276, text figs. 1–3; pp. 286, 287, text figs. 4–6. Paris.

Hodgson, Bryan Houghton

1832.1 On the Mammalia of Nepal. Journ. Asiatic Soc. Bengal, I, No. 8, August, pp. 335–349.

1841.1 Classified Catalogue of Mammals of Nepal. (Corrected to end of 1841, first printed in 1832.) Journ. Asiatic Soc. Bengal, X, N.S., Pt. II, No. 119, pp. 907–916.

New subspecies: *Elephas Isodactylus, Elephas Heterodactylus.*

Hodgson, William Brown

1846.1 Memoir on The Megatherium, and other Extinct Gigantic Quadrupeds of the Coast of Georgia, with observations on its Geologic Features. New York, 47 pp., 1 pl., 1 map, 1 chart.

Hoernes, Moriz

1850.1 [Ueberreste von Wirbelthieren aus den Braunkohlen von Leiding bei Pitten.] Haidinger's Ber. Mitt. Freunden Naturw. Wien, VI, No. 2, pp. 43–46.

1851.1 Die fossilen Mollusken des Tertiär-Beckens von Wien. Jahrb. geol. Reichsanst., II, Heft IV, pp. 93–134. Wien.

Dinotherium, p. 122.

1858 [1848] Dinotherium von Nikolsburg. Haidinger's Ber. Mitt. Freunden Naturw. Wien., III, No. 2, pp. 160, 161.

Hoernes, Rudolf

1881.1 Vorlage von Säugethierresten aus den Braunkohlenablagerungen der Steiermark. Verh. geol. Reichsanst., No. 17, p. 338. Wien.

Mastodon angustidens.

Hofmann, Adolf

1888.1 Beiträge zur Kenntnis der Säugethiere aus den Miocänschichten von Vordersdorf bei Wies in Steiermark. Jahrb. geol. Reichsanst, XXXVIII, pp. 77–82, Taf. I. Wien.

Mastodon angustidens.

1890.1 Ueber einige Säugethierreste aus den Miocänschichten von Feisternitz bei Eibiswald in Steiermark. Jahrb. geol. Reichsanst., XL, pp. 519–526, Taf. IV. Wien.

Mastodon angustidens.

1893.1 Die Fauna von Göriach. Abh. geol. Reichsanst., XV, Heft VI, pp. v+87, 17 Taf., 1 text fig. Wien.

Mastodon angustidens, p. 47.

1909.1 Säugethierreste aus einigen Braunkohlenablagerungen Bosniens u.d. Herzegowina. Wiss. Mitt. Bosn. u.d. Herz., XI, p. 558. Wien. (Original not available.)

Hofmann, Adolf, and A. Zdarsky

1905.1 Beitrag zur Säugetierfauna von Leoben. Jahrb. geol. Reichsanst., LIV, pp. 577–594, Taf. XIV–XVI. Wien.

Mastodon angustidens, p. 584.

Hollaender, Ludwig

1877.1 Die Anatomie der Zähne. Berlin. (*Fide* Weinsheimer, 1883, p. 12; original not available.)

Holland, William Jacob

1905.1 The Hyoid Bone in Mastodon americanus. Ann. Carnegie Mus., III, No. 3, pp. 461–467.

Hollick, Arthur, William Bullock Clark, and Frederic Augustus Lucas

1906.1 See Clark, William Bullock, Arthur Hollick, and Frederic Augustus Lucas.

Hopwood, Arthur Tindell

1926.1 Some Mammalia from the Pliocene of Homa Mountain, Victoria Nyanza. Ann. Mag. Nat. Hist., (9), XVIII, September, pp. 266, 267.

1927.1 On Some Mammalian Remains from Lake Nyasa. Quart. Journ. Geol. Soc. London, LXXXIII, Pt. III, No. 331, pp. 442–444, Pls. xxx–xxxiii. (Appendix I to Frank Dixey's "The Tertiary and Post-Tertiary Lacustrine Sediments of the Nyasan Rift Valley.")

Bunolophodont *Mastodon*, associated with remains of *Hippopotamus*.

1935.1 Fossil Proboscidea from China. Pal. Sinica, (C), IX, Fasc. 3, February, pp. 1–108, Pls. i–viii.

New family: Stegodontidæ, p. 71.

New species: *Trilophodon connexus, T. wimani, T. spectabilis; Tetralophodon exoletus; Pentalophodon sinensis; Stegodon officinalis, S. zdanskyi.*

Revives *Mammuthus* Burnett for the Mammoth, type *Mammuthus borealis*.

Hopwood, Arthur Tindell, and E. J. Wayland

1926.1 The Geology and Palæontology of the Kaiso Bone-Beds. Pt. I. Geology. By E. J. Wayland, pp. 5–11, map, Pl. i. Pt. II. Palæontology. By Arthur Tindell Hopwood, pp. 13–36, Pls. ii–iv, text figs. 1–14. Geol. Surv. Uganda, Occasional Paper No. 2, November.

See especially pages 32, 33, for occurrence of *Elephas* [=*Loxodonta*] *antiquus subsp.* and *Elephas* [=*Archidiskodon*] *all. meridionalis*.

In Part II, W. E. Swinton, Erol Ivor White, and L. R. Cox contribute articles on "Fossil Reptilia," "Fossil Pisces," and "Fossil Mollusca" respectively.

Hornaday, William Temple

1885.1 Two Years in the Jungle. 8vo, London, pp. xxii+512.

Chapter XX—The Indian Elephant.

1905.1 The African Elephant. Bull. New York Zool. Soc., October, No. 19, pp. 237, 238.

Type figure of *Elephas africanus pumilio*.

1928.1 Wild Animal Interviews. 8vo, Charles Scribner's Sons, New York, 310 pp., 43 illustrations.

Horner, William E.

1840.1 Note of the Remains of the Mastodon, and some other extinct animals collected together in St. Louis, Mo. Proc. Amer. Phil. Soc., I, pp. 279–283.

Collection of Mr. Koch at St. Louis, *Missourium kochii, M. giganteus, Tetracaulodon*.

1840.2 Remarks on the Dental System of the Mastodon, with an Account of some Lower Jaws in Mr. Koch's Collection, St. Louis, Missouri, where there is a Solitary Tusk on the Right Side. Proc. Amer. Phil. Soc., I, pp. 307, 308.

Abstract of Horner's paper of 1842.1.

1841.1 Note of the Remains of the Mastodon, and some other extinct animals, collected together in St. Louis, Missouri. Amer. Journ. Sci., XL, No. 1, Jan. 20, pp. 56–59.

Extract from Proc. Amer. Phil. Soc., I, p. 279, collection of Albert Koch.

1841.2 On the Dental System of the Mastodon. Proc. Amer. Phil. Soc., II, Feb. 15, pp. 6, 7.

Note of correction regarding *Tetracaulodon*, in Horner's paper (1840.2).

1842.1 Remarks on the Dental System of the Mastodon, with an Account of some Lower Jaws in Mr. Koch's Collection, St. Louis, Missouri, where there is a solitary Tusk on the right side. Trans. Amer. Phil. Soc., N.S., VIII, Jan. 7, pp. 53–59, Pls. i–iv.

See especially page 58, where the "name Tricaulodon might be established."

Horner, William E., and Isaac Hays

1842.1 Description of an Entire Head, and various other Bones of the Mastodon. Trans. Amer. Phil. Soc., N.S., VIII, pp. 37–48, Pls. i–iv.

From Bucyrus, Crawford Co., Ohio. Species not given.

Hovey, Edmund Otis

1874.1 The Largest Fossil Elephant Tooth yet Described. Proc. Amer. Assoc. Adv. Sci., 22d Meeting, Portland, 1873, p. 112.

From Alameda Co., Calif., in Wabash College, Indiana. [*Parelephas*.]

1908.1 Chester, New York, Mastodon. Editorial. Ann. New York Acad. Sci., XVIII, p. 147, Pl. v.

Howorth, Henry Hoyle

1882.1 The Name "Mammoth." The Field Naturalist, and Scientific Student, No. 2, July, pp. 30–32. Manchester and London.

Full and scholarly exposition as to whether the word is derived from 'ma' signifying earth and 'mut' signifying mole, hence mammoth signifying 'earth-mole'; or from the Arab *Behemot*, in the corrupt Russian 'mammoth.' Howorth reviews the Esthonian-Tartar origin signifying 'earth-mole' and concludes: "The *Russian Mammoth* certainly came from the word *Behemot*." Osborn inclines to the Esthonian-Tartar origin, because of the widespread tradition that the Mammoth lived underground.

1887.1 The Mammoth and the Flood. 8vo, London, pp. xxxii+464.

Hoy, Philo Romayne

1871.1 Dr. Koch's Missourium. Amer. Naturalist, V, pp. 147, 148.

Missourium tetracaulodon = Mastodon americanus

Hunt, James Gibbons

1874.1 [Report on food of the Mastodon.] Proc. Bost. Soc. Nat. Hist., XVII, pp. 91, 92.

Hunter, William

1769.1 Observations on the Bones, commonly supposed to be Elephants Bones, which have been found near the River Ohio in America. Phil. Trans. Roy. Soc. London, LVIII, for the year 1768, pp. 34–45, Tab. iv.

Pseudelephant, or animal incognitum.

Hunter, William Wilson

1868.1 The Annals of Rural Bengal. Second edition. 8vo, New York, pp. xvi+475.

Hutchinson, Henry Neville

1892.1 Extinct Monsters. A Popular Account of some of the Larger Forms of Ancient Animal Life. 8vo, D. Appleton and Co., New York, pp. xx+254, 24 pls., 38 text figs.

1910.1 Extinct Monsters and Creatures of Other Days. A Popular Account of some of the Larger Forms of Ancient Animal Life. 8vo, Chapman and Hall, London, pp. xxxiii+329, 55 pls. 113 text figs.

Ides, Eberhard Ysbrant

1706.1 Three Years Travels from Moscow over-land to China: thro Great Ustiga, Siriania, Permia, Sibiria, Daour, Great Tartary, &c. to Peking, 8vo, London, pp. 7+210, 29 pls., map. (First printed in Dutch by direction of Burgomaster Witzen, formerly Ambassador in England.)

Native belief that the Mammoth was subterranean, pp. 25 and 26.

Illiger, Carolus

1811.1 Prodromus Systematis Mammalium et Avium. 8vo, Berolini, pp. xviii+144 (Mammalia), pp. 145–301 (Aves).

New order: Proboscidea, p. 90.

International Commission on Zoological Nomenclature

See Nomenclature.

Jack, Robert Logan, and Robert Etheridge, Jr.

1892.1 The Geology and Palæontology of Queensland and New Guinea. Text (pp. xxx+768) and plates (68) in two volumes. 4to, Brisbane and London.

Notolephas australis, p. 683 [=*Notelephas australis* Owen, 1882=*Diprotodon*].

Jackson, J. B. S.

1845.1 On the Fossil Bones of Mastodon giganteus from marl pit in New Jersey. Proc. Bost. Soc. Nat. Hist., II, pp. 60–62.

Jacquemin, Émile

1837.1 Mémoire sur les pachydermes fossiles connus jusqu'a ce jour, et Description du nouveau genre Dinotherium de M. Kaup. Mag. Zoologie (Guérin-Méneville), Sept. Année, Cl. I, pp. 1–30, Pls. xxvii–xxix.

Elephas, p. 12; *Mastodon*, p. 15; *Dinotherium*, p. 19, with restoration of *D. giganteum*, Pl. xxix, fig. 1.

Jäger, Georg Friedrich

1847 [1850] Übersicht der fossilen Säugethiere welche in Würtemberg, etc. Nova Acta Acad. Leop. Carol., XXII, pp. 767–934, Tab. lxviii–lxxii.

Mastodon angustidens.

Janensch, Wilhelm

1911.1 Die Proboscidier-Schädel der Trinil-Expeditions-Sammlung. In "Die Pithecanthropus-Schichten auf Java." Herausgegeben vom M. Lenore Selenka und Prof. Max Blanckenhorn, pp. 151–195, Pls. xxi–xxv, text figs. 1–17.

Jentink, Fredericus Anna

1887.1 Catalogue Ostéologique des Mammifères. Mus. Hist. Nat. Pays-Bas, IX, 360 pp., 12 pls. Leiden.

Elephantidæ, pp. 169, 170; *Elephas sumatranus* especially.

Jentzsch, Carl Alfred

1883.1 Ueber einige tertiäre Säugethierreste aus Ost- und Westpreussen. Schrift. phys.-ökonom. Ges. Konigsb., Jahrg. XXIII, Abth. 2, pp. 201–205, Taf. v.

New species: *Mastodon Zaddachi*, p. 202, Taf. v, a, b.

Jerdon, Thomas Claverhill

1874.1 The Mammals of India. 8vo, London, pp. xxxii+335.
Elephantidæ, pp. 228–231.

Jobert, Antoine Claude Gabriel, and l'Abbé Jean Baptiste Croizet

1828.1 See Croizet, Jean Baptiste, and Antoine Claude Gabriel Jobert.

Johnston, Harry H. [Henry Hamilton Johnston]

1898.1 On the Larger Mammals of Tunisia. Proc. Zool. Soc. London, May 3, pp. 351–353.

Joleaud, Léonce

1920.1 Revue de Paléontologie Animale. Rev. gén. Sci. Paris, July 30, pp. 487–500, text figs. 1–11.
Review of Fourtau's species *Mastodon angustidens libyca* and *M. Spenceri*.

1928.1 Eléphants et Dinothériums Pliocènes de l'Éthiopie: Contribution à l'Étude Paléogéographique des Proboscidiens Africains. Compt. Rend., Congrès Géol. Internat., XIV Session, Espagne, 1926, Fasc. III, pp. 1001–1007, 3 pls. Madrid.
Dinotherium found on the banks of the Omo River, tributary of Lake Rodolfe.

Jonas, Louis

1930.1 The Mounting of an Elephant Group. With Appendix by John Jonas. Publ. Amer. Assoc. Museums, N.S., No. 11, 32 pp., 44 text figs.

Joubert de,———

1785 [1788] Mémoire sur des portions de Mâchoire trouvées dans le Cominges en 1783. Mém. Acad. Sci. Toulouse, for 1785, III, pp. 110–113, Pls. vii–x.
Fossil jaw fragments unearthed near Cominges, France [=*Deinotherium*].

Jourdan, Claude

1858.1 [Communication sur des dents de mastodontes fossiles.] Ann. Soc. Imp. Agric. Lyon, (3), II, pp. lxxxiii, lxxxiv, Procès-Verbaux.
New species: [*Mastodon*] *Dissimilis*.

1861.1 Des terrains sidérolitiques. Compt. Rend. Acad. Sci., LIII, pp. 1009–1014. Paris.
New species: *Dinotherium levius*, *Elephas intermedius*.

Judd, John Wesley

1911.1 The Student's Lyell. The Principles and Methods of Geology, as Applied to the Investigation of the Past History of the Earth and Its Inhabitants. 8vo, London, pp. [56]+645, portrait, and 736 text figs.

Kato, T.

1914.1 On the Fossil Proboscidea from Mt. Hanare, Prefecture of Ibaraki. Journ. Geol. Soc. Tokyo, XXI, No. 345, pp. 345–349 (in Japanese). Map and geologic section.
Extinct mastodont.

Katzer, Friedrich

1901.1 Zur näheren Altersbestimmung des "Susswasserneogens" in Bosnien. Centralb. Min. Geol. Pal., No. 8, pp. 227–233. Stuttgart.

Kaup, Johann Jacob

1829.1 Deinotherium giganteum. Isis, [XXII], Heft IV, pp. 401–404, Taf. i.
New genus and species: *Deinotherium giganteum*, p. 401. Figured (Taf. i) with tusks upturned.

1831.1 Fossil. Säugeth. Rheinhessens. (*Fide* de Blainville, Dinotherium, p. 18, of his "Ostéographie.")
D. maximum =synonym of *D. giganteum*. Von Meyer, 1832.2, p. 78, states that this was a MS. name.

1832.1 Ueber zwei Fragmente eines Unterkiefers von Mastodon angustidens Cuv., nach welchen diese Art in die Gattung Tetracaulodon Godmann gehört. Isis, [XXV], Heft VI, pp. 628–631, Taf. xia.
New species: *Tetracaulodon longirostre*.

1832-1839 Description d'Ossements Fossiles de Mammifères . . . de Darmstadt; avec figures lithographiées. 4to, Darmstadt, (Text), folio (Atlas).
1832.2 Cahier I, pp. 1–16—Livraison I, Pls. i–v.
New species: *Dinotherium Cuvieri*. Supplementary description of *Dinotherium giganteum*. Changes *Deinotherium* to *Dinotherium*. In Tab. iv, *D. giganteum* is figured with tusk upturned as in Kaup, 1829.
1833.1 Cahier II, Livraison II, Pls. vi–viii.
1834.1 Cahier III, Livraison III, Pls. ix–xv.
1835.1 Cahier IV, pp. 65–89, Livraison IV, Pls. xvi–xx. Add. Tab. 1, 2, figs. 1–5 (see Kaup, 1841.1, p. 18).
New species: *Mastodon longirostris*, *M. dubius*, *M. grandis*. *Dinotherium medium* appears in caption to Add. Tab. 1, figs. 1–4. *D. giganteum* figured with tusks downturned (Add. Tab. 1, fig. 5).
1839.1 Cahier V, Livraison V, Pls. xxi–xxv (including Pls. xxiii a, b, c). Only Cahier I (1832.2) and IV (1835.1) are cited in the present Memoir.

1833.2 Der Krallen-Phalanx von Eppelsheim, nach welchem Hr. v. Cuvier seinen Riesen-Pangolin, Manis gigantea, aufstellte, gehört zu Dinotherium. Neues Jahrb. Min., pp. 172–176.

1833.3 Dinotherium, Rhinoceros, Dorcathérium, Cervus, Sus. Neues Jahrb. Min., pp. 419, 420.
New species: *Dinotherium medium*.

1833.4 Über die Gattung Dinotherium, Zusätze und Verbesserungen zum ersten Heft der Description d'ossemens fossiles. Neues Jahrb. Min., pp. 509–517, Taf. vii.
Supplementary description of *Dinotherium medium*. New family: Curtognati, p. 516. [See also Bull. Soc. géol. France, 1834, V, p. 444, for note on family name Curtognati.]

1837.1 Sur la place que doit occuper le Dinotherium dans l'échelle animale. Compt. Rend. Acad. Sci., IV, pp. 527–529. Paris.

1841.1 Akten der Urwelt oder Osteologie der urweltlichen Säugethiere und Amphibien. 8vo, Darmstadt, pp. x+54, 14 Tab.
New species: *Dinotherium Königii*, pp. 49, 50.

1857.1 Beitræge zur Næheren Kenntniss der Urweltlichen Sæugethiere. 4to, Darmstadt, Heft III, pp. vi+27, Tab. i–vi.
Mastodon angustidens and *M. arvernensis*.

Kaup, Johann Jacob, and August von Klipstein

1836.1 Beschreibung und Abbildungen von dem in Rheinhessen aufgefundenen colossalen Schedel des Dinotherii gigantei. 4to, Darmstadt, 38 pp. Folio, Atlas, 6 Tab., map. (Giessen, 1843.)

Kaup, Johann Jacob, and Johann Baptiste Scholl

1832.1 Catalogue des plâtres des Ossements fossiles . . . dans le Cabinet d'Histoire Naturelle du Grand-Duc de Hesse. 8vo, Darmstadt, 15 pp., text illustrations. (Original not available.)

1834.1 Verzeichniss der Gypsabgüsse von den ausgezeichnetsten urweltlichen Thierresten des Grossherzoglichen Museum zu Darmstadt. . . . Zweite vermehrte und verbesserte Ausgabe. Verlag von Joh. Phil. Diehl. . . . Ausgegeben im September, 1834. 8vo, Darmstadt, 28 pp. (Original not seen by the present author.)
New species: *Mastodon grandis*, p. 22; *Mastodon dubius*, p. 25.

Kennedy, Ildephons

1785.1 Abhandlung von einigen in Baiern gefundenen Beinen. Neue philosophische. Abh. bayer. Akad. Wiss. München, IV, pp. 1–48, Tab. i, ii.
Five teeth, and an astragalus, best preserved parts of a complete skeleton of *Dinotherium* found in 1762 near Reichenberg, Lower Bavaria.

Kerr, Robert, Carolus Linnæus, and Johann Fridrich Gmelin

1792.1 The Animal Kingdom or Zoological System, of the Celebrated Sir Charles Linnæus; Class I. Mammalia: Containing a Complete Systematic Description, Arrangement, and Nomenclature, of all the Known Species and Varieties of the Mammalia . . . , being a translation of that part of the Systema Naturæ, as lately published, with great improvements, by Professor Gmelin of Goettingen. Together with Numerous Additions from more Recent Zoological Writers. 4to, London, I, Class I (Mammalia), Class II (Birds), pp. 8+28+644, 9 pls. (See Linnæus for the "Systema Naturæ.")
New species: *Elephas americanus* p. 116. *Elephas maximus* treated p. 115.

Khomenko, J.

1912.1 Mastodon arvernensis Croiz. et Job. nova var. progressor des sables du Pliocène supérieur dans le Sud-Bessarabie. Annuaire Géol. Min. Russie, XIV, Livr. 6, pp. 159–166. 1 pl. Novo Alexandria.
New variety: *Mastodon arvernensis* Croiz. et Job. var. *progressor*.

Kittl, Ernst Anton Leopold

1885.1 Die fossile Säugethier-Fauna von Maragha in Persien. Verh. geol. Reichsanst., Nos. 16, 17, pp. 397–399. Wien.
Mastodon pentelici treated.

1887.1 Beiträge zur Kenntniss der fossilen Säugethiere von Maragha in Persien. I. Carnivoren. Ann. naturhist. Hofmus., II, pp. 317–338, Taf. xiv–xviii. Wien.
Mastodon pentelici and *Mastodon* sp. cited, p. 320.

Kittl, Ernst Anton Leopold—Continued

1908.1 Das Dinotheriumskelett von Franzensbad im k.k. naturhistorischen Hofmuseum. Wochenschrift "Urania," I, No. 12. text fig. Wien.

Klähn, Hans

1922.1 Die badischen Mastodonten und ihre süddeutschen Verwandten. 8vo, Berlin, pp. xii+134, 31 text figs., table.

New species: *Mastodon steinheimensis, M. esselbornensis, M. engelswiesensis, M. wahlheimensis, M. gigantorostris, M. minutoarvernensis, M. gigantarvernensis.*

1931.1 Die Mastodonten des Sarmatikum von Steinheim a. Alb. Palaeontogr. Supplement-Band VIII, Teil XII, pp. 1–36, Taf. I–IV, text figs. 1–19.

New subspecies: *Mastodon angustidens* Cuv. *steinheimensis* Klähn. Same molar formerly referred by Fraas (1870) to *Mastodon arvernensis*; made the type of *M. steinheimensis* by Klähn in 1922.

Klipstein, August von, and Johann Jacob Kaup

1836.1 See Kaup, Johann Jacob, and August von Klipstein.

Knight, Wilbur Clinton

1903.1 Remains of Elephants in Wyoming. Science, N.S., XVII, No. 438, p. 828.

Koch, Albrecht Karl (Albert Carl)

1839.1 The Mammoth (Mastodon? Eds.). Amer. Journ. Sci., (1), XXXVI, pp. 198–200.

Copied from article in the Philadelphia Presbyterian of Jan. 12, 1839. Discovery of fossil bones in Gasconade County, Mo., in 1838 (?).

1839.2 Remains of the Mastodon in Missouri. Amer. Journ. Sci., (1), XXXVII, pp. 191, 192. Article signed "A. Koch, Proprietor of the St. Louis Museum. St. Louis Com. Bulletin of June 25, quoted in Phil. Nor. Am., July 11, 1839."

Account of the type head of Koch's Missourian, so named by Dr. Koch in honor of the State in which it was found; later? (1840.1, p. 2) he described this cranium under the name of *Missourium Kochii*.

1840.1(?) Fossil Remains. (Churchill and Stewart), 8 pages and 1 plate.

The copy of this paper bears no title-page or date; in Bulletin 2 of the Geological Survey of Missouri (p. 123) it is stated that "the pamphlet was probably published before 1841." The original is in the St. Louis Public Library.

New genus and species: *Missourium Kochii*, p. 2 (Missourium occurs on page 1). Type head found May, 1839, 22 miles south of St. Louis, Jefferson Co., in vicinity of Sulphur Springs, on Little Rock Creek, Missouri. Mentions (p. 6) other large bones which he disinterred in 1838 on a farm in Gasconade County, Mo.

1841.1 Description of the Missourium, or Missouri Leviathan; together with its supposed habits. Indian Traditions concerning the location from whence it was exhumed; also, Comparisions of the Whale, Crocodile, and Missourium, with the Leviathan, as described in the 41st chapter of the book of Job. 16 pages, no plate. Printed by Chas. Keemle, St. Louis, 1841 (on title page); St. Louis, 1840 only (on cover). Rare edition, in St. Louis Mercantile Library.

This St. Louis edition gives a description of the skeleton excavated in March of 1840 (*fide* Dublin edition of 1843, pp. 9, 12) by Doctor Koch near the shores of the river La Pomme de Terre, a tributary of the Osage River, Benton County, Missouri; regarded by him as the same animal as his *Missourium* (p. 13), naming it *Leviathan missourii*.

The next edition (1841, Louisville, Ky., Prentice and Weissinger, Printers), 20 pages, is practically the same as the St. Louis edition. Original in the Missouri Historical Society, St. Louis.

Another edition (London, E. Fisher, 1841, 24 pp.) includes the new species *Tetracaulodon Osagii* (p. 1). *Tetracaulodon Tapyroides* is also cited.

1842.1 [On the Genus Tetracaulodon.] Proc. Geol. Soc. London, III, pp. 714–716.

Reviews *Tetracaulodon Godmanii, T. kochii, T. Tapiroides.*

1843.1 Description of the Missourium Theristocaulodon (Koch). or Missouri Leviathan, (Leviathan missouriensis), together with its Supposed Habits, and Indian Traditions, also Comparisons on the Whale, Crocodile, and Missourium, with the Leviathan. As Described in the 41st chapter of the book of Job. Fifth edition, Enlarged, Dublin, 1843, 28 pp., figure of skeleton on cover. Printed by C. Crookes.

1845.1 Die Riesenthiere der Urwelt oder das neuentdeckte Missourium Theristocaulodon (Sichelzahn aus Missouri) und die Mastodontoiden im Allgemeinen und Besondern. 8vo, Berlin, pp. viii+99, 8 pls.

New species: *Mastodon rugatum*, "*Mastodon angustidens*" (=*Dinotherium angustidens*). Apparently Koch erroneously attributed *Mastodon arborense* to von Meyer. A general review of the known species of *Mastodon*.

1857.1 Mastodon Remains, in the State of Missouri, together with Evidences of the Existence of Man contemporaneously with the Mastodon. Trans. Acad. Sci. St. Louis, I, pp. 61–64.

Concludes that the bones found in Gasconade County, Mo., (see Koch, 1839.1) belong to *Mastodon giganteus* (p. 62).

1858.1 [On the Bones of Mastodon.] Trans. Acad. Sci. St. Louis, I, pp. 116, 117.

Koenigswald, G. H. Ralph

1933.1 Beitrag zur Kenntnis der Fossilen Wirbeltiere Javas. Wetenschappelijke Mededeelingen, Dienst Mijnbouw Nederl.-Indië, I Teil, No. 23, pp. 1–178, Taf. I–XXVIII, text figs. 1–9.

New family: Cryptomastodontidæ, p. 119. New genus: *Cryptomastodon*, p. 112. New species: *Cryptomastodon martini*, pp. 111, 112, and *Stegodon trigonocephalus praecursor*, p. 104. [*Cryptomastodon* is a (?) Sirenian (cf. *Desmostylus.*)]

1934.1 Zur Stratigraphie des javanischen Pleistocän. De ingenieur Nederl.-Indië, No. 11, pp. 185–201, Taf. III, IV.

New subspecies: *El. hysudricus hysudricus, El. hysudricus primitivus, El. meridionalis antiquus, El. meridionalis meridionalis, (El. [illegible] americanus)*?, p. 187. Lists *Elephas* ex. aff. *namadicus, El.* cf. [illegible] *Stegodon trigonocephalus* cf. *praecursor* von Koenigswald, and [illegible] *t. trigonocephalus* Martin as occurring in Java, p. 191. Regards the [illegible] fauna, especially *Stegodon airawana*, as of Middle [illegible] age, pp. 197, 200.

1935.1 Die fossilen Saugetierfaunen Javas. Proc. Akad. Wet. Amsterdam, XXXVIII, No. 2, pp. 188–198. (In Dutch language.)

1935.2 Vorläufige Mitteilung über das Vorkommen von Tectiten auf Java. Proc. Akad. Wet. Amsterdam, XXXVIII, No. 3, pp. 287–289.

Koken, Ernst

1885.1 Ueber fossile Säugethiere aus China. Geol. u. Pal. Abh., III, Heft II, pp. 31–114, Taf. VI–XII. Berlin.

New variety: *Mastodon perimensis* var. *sinensis*, p. 34. Treatment of *Stegodon*, pp. 34–41.

Köllner, Karl

1882.1 Die Geologische Entwicklungsgeschichte der Säugethiere. 8vo, Wien, pp. viii+98.

Considers *Dinotherium* as direct ancestor of *Mastodon*, p. 45.

König, F.

1914.1 Über die Wirbeltierfunde bei den Österreichischen Bergwerken. Österr. Zeitschr. Berg-und-Hüttenwesen, Wien. Pl. I, figs. 7 and 8. (Original not available; *fide* Abel, 1919, p. 221.)

Kowalewsky, Wladimir

1873.1 On the Osteology of the Hyopotamidæ. Phil. Trans. Roy. Soc. London, CLXIII, pp. 19–94, Pls. XXXV–XL.

1874.1 Monographie der Gattung Anthracotherium Cuv. und Versuch einer natürlichen Classification der fossilen Hufthiere. Palaeontogr., XXII, pp. I–IV, 133–347, Taf. VII–XVII.

Published in three parts: 1873 (pp. 131–210, Taf. VII–IX); 1874 (pp. 211–347, Taf. X–XVII).

Krüger, Johann Friedrich

1823.1 Geschichte der Urwelt, Zweiter Theil. 4to, Gottfried Bass, Quedlinburg and Leipzig, pp. viii+966+1 unnumbered page.

New species: *Elephas antiquitatis*, p. 832. "Eleph. Mastodontus. Mastodon Ohioticum Oken. Mast. giganteum. Mammut ohioticum. Ohiother. Grosses Mastodon. Amerikanisches Mammuth. Nordamerikanischer Elephant. Le grand Mastodonte," p. 843.

Kunz, George Frederick

1916.1 Ivory and the Elephant in Art, in Archaeology and in Science. 8vo, New York, pp. xxvi+527, 155 pls., 4 folding plates, 41 text figs.

Full and interesting history of ivory in art and of the artistic and commercial uses of ivory from early times.

Kutorga, Stephan Semenovich

1838.1 Beitrag zur Kenntniss der organischen Ueberreste des Kupfersandsteins am westlichen Abhange des Urals. 8vo, St. Petersburg, 38 pp., 7 pls.

Syodon biarmicum, p. 19.

[illegible] Kutorga, 1838, listed by Palmer as belonging to the "Ungulata? Proboscidea." [illegible] Kutorga in his original description placed *Syodon* in the "Pachydermes ordinaires" of Cuvier, which group contained the hippopotami, pigs and peccaries. Agassiz, in 1842, referred this genus to the Pachydermata, but Bronn in 1848 identified it as a fish, where it more probably belongs (Colbert, June 1, 1936).

Lacépède, Bernard Germain Étienne de la Ville, and Georges Léopold Chrétien Frédéric Dagobert Cuvier

1802.1 See Cuvier, Georges Léopold Chrétien Frédéric Dagobert, and Bernard Germain Étienne de la Ville Lacépède.

Lambe, Lawrence Morris

1898.1 On the Remains of Mammoths in the Museum of the Geological Survey Department. Ottawa Nat., XII, pp. 136, 137.

1912.1 The Past Vertebrate Life of Canada. (Presidential Address.) Trans. Roy. Soc. Canada, V, Sec. IV, 1911, pp. 3–15.

Among the Pleistocene mammals are included *M. americanus* and *E. primigenius*.

Lang, Herbert

1925.1 Problems and Facts about Frozen Siberian Mammoths (Elephas primigenius) and Their Ivory. Zoologica, New York Zool. Soc., IV, No. 2, Jan. 8, pp. 25–53, figs. 9–19.

Lankester, Edwin Ray

1899.1 Note on the Molar of a Trilophodont Mastodon from the Base of the Suffolk Crag. Geol. Mag., Dec. IV, N. S., VI, pp. 289–292, Pl. xi.

Determined and figured as an M^2 of *Mastodon angustidens* var. *latidens* [=*Zygolophodon* sp.].

Lapham, Increase Allen

1855.1 On the Number of Teeth of the Mastodon giganteus. Proc. Bost. Soc. Nat. Hist., V, pp. 133–136.

Lartet, Édouard

1836.1 Nomenclature des mammifères et des coquilles qu'il a trouvés dans un terrain d'eau douce près de Simorre et de Sansan (Gers). Bull. Soc. géol. France, (1), VII, May 26, pp. 217–220.

New subspecies: *M. tapiroïdes-minus*, *M. angustidens minus*. Attributes the name *Dinotherium secundarium* to Kaup, p. 218.

1851.1 Notice sur La Colline de Sansan, suivie d'une Récapitulation des Diverses Espèces d'Animaux Vertébrés Fossiles. . . . Avec une Liste des Coquilles Terrestres, Lacustres et Fluviatiles Fossiles . . . Par MM. Noulet, Dupuy, deBoissy. 8vo, Auch, 45 pp., 1 pl. ("Extrait de l'Annuaire du Département du Gers, Année 1851.")

New species: *Mastodon Simorrense*, p. 24; *M. Gaujaci*, p. 27.

1859.1 Sur la dentition des proboscidiens fossiles (Dinotherium, Mastodontes et Éléphants) et sur la distribution géographique et stratigraphique de leurs débris en Europe. Bull. Soc. géol. France, (2), XVI, pp. 469–516, Pls. xiii–xv.

See especially dentition of *Dinotherium*, Pl. xiii. [Type figure (Pl. xv, fig. 3, as *M. tapiroides*) of *Turicius turicensis simorrensis* Osborn, 1926.]

1865.1 [Paleontologie.—M. Milne Edwards communique à l'Académie la Lettre suivante de M. Lartet, relative à une lame d'ivoire fossile trouvée dans un gisement ossifère du Périgord, et portant des incisions qui paraissent constituer la reproduction d'un Éléphant à longue crinière.] Compt. Rend. Acad. Sci., LXI, pp. 309–311. Paris.

Lartet, Édouard, and Henry Christy

1875.1 Reliquiæ Aquitanicæ; being Contributions to the Archæology and Palæontology of Périgord and the Adjoining Provinces of Southern France. Edited by Thomas Rupert Jones. 4to, London, pp. xxii+302+204, 87 pls., 3 maps, 132 woodcuts.

Lartet, Édouard, and Albert Gaudry

1856.1 See Gaudry, Albert, and Édouard Lartet.

Lathrop, S. Pearl

1851.1 Mastodon in Northern Illinois. Amer. Journ. Sci., (2), XII, p. 439.

Laufer, Berthold

1925.1 Ivory in China. Field Museum of Natural History Anthropology Leaflet 21, 78 pp., 10 pls.

Laurillard, Charles Léopold

1846.1 Mastodonte. In Charles d'Orbigny's Dictionnaire Univ. d'Hist. Nat., VIII, pp. 27–32. Paris.

Laurillard, Charles Léopold, Georges Léopold Chrétien Frédéric Dagobert Cuvier, and Mercier

1850-1856 See Cuvier, Georges Léopold Chrétien Frédéric Dagobert, Charles Léopold Laurillard, and Mercier.

Leakey, Louis Seymour Bazett

1934.1 Adam's Ancestors. 8vo, New York, pp. xix+244, 12 pls., 30 text figs.

Dinotherium, found at Kanam, 4 miles from Kavirondo Gulf of Lake Victoria, Africa, p. 206, also *Homo kanamensis*, p. 207.

Le Hon, Henri

1867.1 Temps Antédiluviens et Préhistoriques. L'Homme Fossile en Europe son Industrie, ses Mœurs, ses Œuvres d'Art. 8vo, Brussels and Paris; Première Partie, pp. 1–256, illustrated.

Leidy, Joseph

1853.1 The Ancient Fauna of Nebraska; or a Description of Remains of Extinct Mammalia and Chelonia, from the Mauvaises Terres of Nebraska. Smithson. Cont. to Knowledge, VI, Art. VII, June, pp. 1–126, Pls. i–xxiv, 1 map.

Mentions *E. americanus*, *E. primigenius*, and *M. giganteus* as of the Pliocene deposits of America.

1858.1 List of Extinct Vertebrata, the remains of which have been discovered in the region of the Missouri River with remarks on their Geological Age. Proc. Acad. Nat. Sci. Phila., IX, for the year 1857, Jan. 7, 1858, pp. 89–91.

M. ohioticum, small fragments of molar teeth. Leidy thought they belonged to the "post-pliocene age of the upper Missouri country."

1858.2 [On new species of Mastodon and Elephant from Nebraska, Mastodon mirificus, Elephas imperator.] Proc. Acad. Nat. Sci. Phila., X, April, p. 10.

1858.3 [Remarks on a cast of a Mastodon tooth, etc.] Proc. Acad. Nat. Sci. Phila., X, April, p. 12.

Cast of true "Baltimore mastodon" tooth referred by Harlan to *M. longirostris*. Original came from Greensburgh, Caroline County, Md.

Tapirus mastodontoides (see Richard Harlan's "Fauna Americana," 1825, p. 224; Medical and Physical Researches, p. 265) equals Mastodon, according to Leidy, Cooper, and Hays.

1858.4 Notice of Remains of Extinct Vertebrata, from the Valley of the Niobrara River, collected during the Exploring Expedition of 1857, in Nebraska, under the command of Lieut. G. K. Warren, U. S. Top. Eng., by Dr. F. V. Hayden, geologist to the Expedition. Proc. Acad. Nat. Sci. Phila., X, April, pp. 20–29.

M. (*Tetralophodon*) *mirificus* Leidy and *Elephas* (*Euelephas*) *imperator* Leidy.

1859.1 On extinct Vertebrata from the Judith and Great Lignite Formations of Nebraska. Proc. Amer. Phil. Soc., VII, pp. 10, 11.

Mastodon and *Elephas* of the (?)Pliocene.

1859.2 [On a Mastodon tooth from Honduras, teeth and fragments of teeth of Mosasaurus from the green sand of New Jersey.] Proc. Acad. Nat. Sci. Phila., XI, p. 91.

Tooth *M. ohioticus* (?) from Tambla, Honduras. [In 1869, p. 242, regarded by Leidy as possibly a molar of *M. andium*. Referred by Osborn to *Rhynchotherium browni* in present Memoir, Fig. 454, p. 484].

1859.3 Description of Vertebrate Fossils in "Post-Pleiocene Fossils of South Carolina," by Francis S. Holmes, Nos. 8–10, pp. 99–110, Pls. xv–xx.

Elephas americanus and *M. ohioticus*, p. 108, also Pls. xviii and xix.

1866.1 [Remarks upon fossil bones of the elephant, etc., found in a salt mine on the Island of Petite Anse, Louisiana.] Proc. Acad. Nat. Sci. Phila., XVIII, p. 109.

1867.1 [Exhibition of teeth of mastodon ohioticus from Big Bone Lick, Ky.] Proc. Acad. Nat. Sci. Phila., XVIII, for the year 1866, Feb. 13, 1867, p. 290.

1868.1 Notice of some Vertebrate Remains from Harden Co., Texas. Proc. Acad. Nat. Sci. Phila., XX, pp. 174–176.

Mastodon americanus equals *M. ohioticus* or *M. giganteus* of authors, first used by Leidy.

1869.1 The Extinct Mammalian Fauna of Dakota and Nebraska, including an account of some Allied Forms from other localities, together with a Synopsis of the Mammalian Remains of North America. Journ. Acad. Nat. Sci. Phila., (2), VII, pp. 1–472, Pls. i–xxx.

M. mirificus, type jaw fragment, figured in Pl. xxv, figs. 1, 2; *E. imperator*, molar, figured in Pl. xxv, fig. 3. New species: *Mastodon obscurus*, molar, figured in Pl. xxvii, fig. 13. *M. obscurus* [=referred *Serridentinus obliquidens* Osb.], Pl. xxvii, fig. 16; *M. andium* (?), Tambla molar, figured in Pl. xxvii, fig. 14 [=*Rhynchotherium*].

1870.1 [On fossil Mammalia from Idaho, Utah, and Oregon.] Proc. Acad. Nat. Sci. Phila., XXII, pp. 66, 67.

Idaho: *M. mirificus*, Niobrara Pliocene fauna, collected by Clarence King.

1870.2 [On Fossils from the vicinity of Burlington, Kansas.] Proc. Acad. Nat Sci. Phila., XXII, pp. 69–71.

Kansas: *E. americanus*, plate from a large molar.

Leidy, Joseph—Continued

1871.1 [On Mastodon remains in the Warren Museum, the museum at Cambridge, and at Amherst College, and on a new species of Mastodon.] Proc. Acad. Nat. Sci. Phila., XXII, for the year 1870, March 14, 1871, pp. 96–99.

Amherst Museum: Fragment of tusk from Dry Creek, Stanislaus Co., Calif., resembling *M. angustidens*, perhaps may equal *M. obscurus;* Leidy makes it the type of *M. shepardi* [subsequently referred by Osborn to *Rhynchotherium*]; fragment of lower jaw, containing last molar, from Contra Costa Co., Calif., species indeterminate, but tooth similar to type of *M. obscurus* from Maryland, possibly referable to *M. shepardi*.

1871.2 Report on the Vertebrate Fossils of the Tertiary Formations of the West. [4th Annual] Preliminary Rept. U. S. Geol. Surv. of Wyo. and Portions of Contiguous Territories (being a Second Annual Report of progress), conducted under the authority of the Secretary of the Interior, by F. V. Hayden, United States geologist. Washington: Government Printing Office., Pt. IV, Chap. IV, pp. 340–370.

Proboscidea, pp. 358, 359.

1871.3 Notes on the American Mastodon and other Fossils. Amer. Journ. Sci., (3), I, January, pp. 63–65.

1871.4 [On fossil bones from California—Mastodon, Horse, etc.] Proc. Acad. Nat. Sci. Phila., XXIII, May 9, p. 50.

Fragment of inferior molar, apparently of *M. americanus*, Table Mt., Tuolumne Co., Calif.

1871.5 Remains of Mastodon and Horse in North Carolina. Proc. Acad. Nat. Sci. Phila., XXIII, July 11, p. 113.

Mastodon americanus, from Goldsboro', Lenoir Co., N. C.

1871.6 Remarks on Mastodon, etc. of California. Proc. Acad. Nat. Sci. Phila., XXIII, Oct. 24, pp. 198, 199.

Mastodon shepardi from Stanislaus Co., and Mastodon from Contra Costa Co., Calif.

1871.7 Remarks on Fossil Vertebrates from Wyoming. Amer. Journ. Sci., (3), II, November, pp. 372, 373.

1872.1 Remarks on Mastodon from New Mexico. Proc. Acad Nat. Sci. Phila., XXIV, Sept. 3, p. 142.

Molar supposed to belong to *M. obscurus;* part of symphyseal prolongation of the jaw containing portions of tusks, resembling the European *M. angustidens;* portion of an upper tusk, with band of enamel, described as *M. Sheppardi. Rhynchotherium* of the Genoa [Geneva] Museum may equal *M. obscurus*.

1873.1 Contributions to the Extinct Vertebrate Fauna of the Western Territories. Rept. U. S. Geol. Surv. Terr., I, 4to, 358 pp., 37 pls.

Mastodon obscurus, figured Pls. xxi, xxii; refigures portion of type tusk of *M. shepardi* in Amherst Museum.

1874.1 Remarks on Fossil Elephant Teeth. Proc. Acad. Nat. Sci. Phila., XXV, for the year 1873, Feb. 17, 1874, pp. 416, 417.

Elephas columbi from Mexico; relation of Mastodon and Elephant tooth structure.

1875.1 Remarks on Elephant Remains. Proc. Acad. Nat. Sci. Phila., XXVII, June 1, p. 121.

Teeth of *Elephas americanus*, from near Chadd's Ford, Delaware Co., Pa., and from California, respectively, now preserved in the cabinet of Wabash College, Indiana. Drawings of an elephant tooth dredged at confluence of Monongahela and Allegheny rivers.

1876.1 Mastodon andium. Proc. Acad. Nat. Sci. Phila., XXVIII, April 25, p. 38.

From Amazon. Fragment of mandible, from Tarrapota, near town of Chasuta, on Huallaga River, a branch of the Amazon, eastern Peru.

1877.1 Description of Vertebrate Remains, chiefly from the Phosphate Beds of South Carolina. Journ. Acad. Nat. Sci. Phila., 1874–1881, (2), VIII, pp. 209–261, Pls. xxx–xxxiv.

Disposed to consider most of the elephant remains of North America, including molar teeth with comparatively thin plates, as pertaining to a common species under De Kay's name *E. americanus*.

1884.1 Fossil Bones from Louisiana. Proc. Acad. Nat. Sci. Phila., XXXVI, April 1, p. 22.

M. americanus fragments from New Iberia, La.

1884.2 Vertebrate Fossils from Florida. Proc. Acad. Nat. Sci. Phila., XXXVI, June 3, pp. 118, 119.

"Young mastodon" fragments from Florida.

1886.1 Mastodon and Llama from Florida. Proc. Acad. Nat. Sci. Phila., XXXVIII, March 23, pp. 11, 12.

New species: *M.* (*Trilophodon*) *floridanus* Leidy; tusk fragments indicate enamel band, molar (last inferior) larger than in *M. angustidens* or *M. andium*.

1886.2 Caries in the Mastodon. Proc. Acad. Nat. Sci. Phila., XXXVIII, April 6, p. 38.

Inference based on certain imperfections in the tooth.

1887.1 Fossil bones from Florida. Proc. Acad. Nat. Sci. Phila., XXXIX, Dec. 13, pp. 309, 310, text fig.

M. floridanus fragments from Florida, Mixson's bone bed, near Archer, Levy Co.

1889.1 Fossil Vertebrates from Florida. Proc. Acad. Nat. Sci. Phila., XLI, June 18, pp. 96, 97.

Premolar of *E. columbi*, Ocala, Florida.

1889.2 Description of Mammalian Remains from a Rock Crevice in Florida. Trans. Wagner Free Inst. Sci., II, December, pp. 13–17.

Elephas from Ocala, Florida, p. 17. Milk molars, Pl. III, figs. 6–9.

1889.3 Description of Vertebrate Remains from Peace Creek, Florida. Trans. Wagner Free Inst. Sci., II, pp. 19–31.

Elephas columbi, last upper molar, Pl. VII, p. 23; also part of right ramus of mandible containing last molar tooth, Pl. VIII, fig. 2, p. 23.

1889.4 Notice of Some Mammalian Remains from the Salt Mine of Petite Anse, Louisiana. Trans. Wagner Free Inst. Sci., II, pp. 33–40.

Mastodon americanus, fragments of vertebræ and other bones, also well-preserved molar teeth, the last two of the lower series.

1890.1 Fossil Vertebrates from Florida. Proc. Acad. Nat. Sci. Phila., XLII, May 13, pp. 64, 65.

Mastodon floridanus fragments from Florida. Confirms H. von Meyer's inference that "two premolars succeeded the series of deciduous molars."

1890.2 Mastodon and Capybara of South Carolina. Proc. Acad. Nat. Sci. Phila., XLII, July 29, pp. 184, 185.

New species: *Mastodon rugoidens;* founded on molar fragment from Beaufort Co., S. C.

1892.1 [List of Vertebrata from the Pliocene Beds of Florida.] See Dall and Harris, Bull. U. S. Geol. Surv. No. 84, Correlation Papers, Neocene, pp. 129, 130.

Mastodon floridanus, Alachua clays, Archer. *Elephas columbi*, Ocala, Peace Creek, Caloosahatchie; *Mastodon serridens*, *Equus beds*.

Leidy, Joseph, and Frederic Augustus Lucas

1896.1 Fossil Vertebrates from the Alachua Clays of Florida. Trans. Wagner Free Inst. Sci., IV, pp. vii–xiv, 15–61, Pls. I–XIX.

Supplementary description with type and metatype figures of *Mastodon floridanus*.

Leney, Frank

1902.1 A List of the Type, Figured, and Described Fossils in the Norwich Castle Museum. Geol. Mag., Dec. IV, N.S., IX, pp. 166–171, 220–231.

Type of *E. giganteus intermedius* Gunn, listed as in the Norwich Museum.

A complete and most valuable revision of the Forest-Bed fauna contained in the Norwich Castle Museum, by the Assistant Curator. See also "Memorials of John Gunn," 1891.

Lenk, Hans, and Johannes Felix

1891.1 See Felix, Johannes, and Hans Lenk.

Lesson, René Primevère

1842.1 Nouveau Tableau du Règne Animal. Mammifères. 8vo, Paris, 204 pp.

New family: Elephasideæ, p. 156. New species: *Mastodon Brasiliensis* Lund, p. 157.

Lichtenstein, Karl Martin Heinrich

1840.1 [Mittheilung über mehrere im nördlichen America gefundene Pachydermen.] Isis, [XXXIII], Heft XII, pp. 903–906.

Liddell, Henry George, and Robert Scott

1883.1 A Greek-English Lexicon. 7th edition. Harper and Brothers, New York.

History of the word Elephant, p. 454.

Lindgren, Waldemar

1911.1 The Tertiary Gravels of the Sierra Nevada of California. U. S. Geol. Surv., Profess. Paper 73, 226 pp., 28 pls., 16 text figs.

Link, Heinrich Friedrich

1807.1 Beschreibung Naturalien-Sammlung der Universität zu Rostock (4), p. 3. (Original not available; *fide* Sherborn, "Index Animalium," 1928, Pt. XV, p. 3845.)

Linnæus, Carolus (Karl von Linné)

1735.1 Systema Naturæ, First Edition. Folio, Lugduni Batavorum, 12 pp.

Elephas placed in same division of quadrupeds with rhinoceros, see p. 10

Linnæus, Carolus (Karl von Linné)—Continued

1754.1 Animalia Rariora, Imprimis, et Exotica. Mus. Adolph Frid. Regis, Holmiæ [Stockholm], pp. xxx+96, 33 pls.
The specific name *Elephas indicus* first appears in this volume, p. 11.

1758.1 Systema Naturæ, Editio Decima, Reformata, I, pp. 824+iii, Appendix, 3 pp. 8vo, Holmiæ, Impensis Direct. Laurentii Salvii.
The "Systema Naturæ" consists of many editions, namely, 1735, 1736, 1740, 1744, 1747, 1748, 1753, 1756, 1758–59, 1760, 1762, 1766–68 [the last edition personally supervised by Linnæus], 1767–70, 1772, 1773, 1788–93, 1789–96; the English editions are dated 1802, 1806. The present edition, of 1758, known as the Decima, Reformata, was officially adopted by the V International Congress of Zoology, held at Berlin in 1901, and "is accepted as the starting point of zoological nomenclature and of the Law of Priority." (Inter. Rules of Zool. Nomenclature, Art. 26, Opinions, Nos. 3, 12, 13, 15, 16, 51, 52.) [Errata (Appendix of 3 pp.) listed at close of reprinted edition of 1894.]
The present author has made photographic excerpts from the first edition (1735, p. 10) and from the original tenth edition (1758, p. 33). In the tenth edition (1758) the name *Elephas maximus* is substituted for *Elephas indicus*, 1754, p. 11.

Linnæus, Carolus, Johann Fridrich Gmelin, and Robert Kerr

1792.1 See Kerr, Robert, Carolus Linnæus, and Johann Fridrich Gmelin.

Lockhart, Charles François

1853 [1854] Note sur un nouveau dépôt d'ossements fossiles dans le département du Loiret. Bull. Soc. géol. France, (2), XI, pp. 50–53.
Dinotherium, p. 50.

Logan, William Edmond

1863.1 Geological Survey of Canada, Report of Progress from Its Commencement to 1863, pp. xxvii+983, 498 woodcuts. Atlas of maps and sections.
Cites (p. 914) *Euelephas jacksoni* as found north of Hamilton, and gives four figures on pp. 966, 967.

Lomnicki, Aloys Maryan

1914.1 Wykrycie mamuta i nosorozca dyluwialnego w Staruni. Wykopaliska Staruńskie, Muzeum Imienia Dzieduszyckich we Lwowie, XV, pp. 3–7, 4 text figs.

Loomis, Frederic Brewster, and James Williams Gidley

1926.1 See Gidley, James Williams, and Frederic Brewster Loomis.

Lorenzo, Giuseppe, De

See De Lorenzo, Giuseppe.

Lortet, Louis, and Ernest Chantre

1872 [1876] Études Paléontologiques dans Le Bassin du Rhone. Période Quaternaire. Arch. Mus. hist. nat. Lyon, I, pp. 59–130, Pls. iii, xi, xii, xvi–xxi, and frontispiece.
Excellent frontispiece of mounted skeleton of *Elephas intermedius* Jourdan.

1878 [1879] Études Paléontologiques dans Le Bassin du Rhone. Période Tertiaire. Recherches sur Les Mastodontes et Les Faunes Mammalogiques qui les Accompagnent. Arch. Mus. hist. nat. Lyon, II, pp. 285–311, Pls. i–xix.
Detailed treatment of *M. dissimilis*, with numerous figures, also *M. affinis*.

Lucas, Frederic Augustus

1900.1 The Truth About the Mammoth. McClure's Mag., XIV, February, pp. 349–355, 5 figs.

1901.1 Animals of the Past. 8vo, McClure, Phillips & Co., New York, pp. xx+258, 16 pls., 26 text figs.
Mastodon and Mammoth.
The dates of the seven editions of this book are: 1915, 1916, 1917, 1920, 1922, 1929; it was reprinted in 1913 as Amer. Mus. Nat. Hist. Handbook Series No. 4.

1902.1 North American Elephantids. Science, N.S., XV, No. 379, Apr. 4, pp. 554, 555.
Mastodon floridanus must be known as *M. obscurus*, a fact which the author overlooked when editing Dr. Leidy's posthumous paper on fossil vertebrates from the Alachua clays.

1902.2 Orange County Mastodons. Science, N.S., XVI, No. 408, Oct. 24, p. 669.
Suggests that Mr. Gordon was mistaken in supposing that the bones of last three mastodons discovered in Orange County were found in their proper relative positions. If, however, he referred to the Peale specimens, these were fairly complete.

1902.3 Animals Before Man in North America: their Lives and Times. 8vo, D. Appleton and Co., New York, pp. vii+291, 6 pls.
Mastodon and Mammoth.

1906.1 Systematic Paleontology of the Pleistocene Deposits of Maryland. Mammalia. Maryland Geol. Surv., "Pliocene and Pleistocene," pp. 157–169, Pls. xxxiv–xl. 4to, Johns Hopkins Press, Baltimore.
Mammut americanus (Kerr), *Elephas primigenius*, *E. columbi*, *E. imperator*.

1908.1 The Size of the Mammoth. Nature, LXXVIII, No. 2028, Sept. 10, p. 443.

Lucas, Frederic Augustus, William Bullock Clark, and Arthur Hollick

1906.1 See Clark, William Bullock, Arthur Hollick, and Frederic Augustus Lucas.

Lucas, Frederic Augustus, and Joseph Leidy

1896.1 See Leidy, Joseph, and Frederic Augustus Lucas.

Ludolf, Heinrich Wilhelm [?Hiob]

1696.1 Grammatica Russica. 8vo, Oxonii, pp. 13+97.
Mammotovoi kost, p. 92. Mammontova kost (*fide* Fischer de Waldheim, 1830–1837, p. 111).

Lugn, Alvin L., and Charles Bertrand Schultz

1934.1 The Geology and Mammalian Fauna of the Pleistocene of Nebraska. Neb. State Mus., Bull. 41, I, Pts. I and II, October, pp. 319–393, figs. 184–186, and Table A.
Pt. I, Outline of Pleistocene Geology of Nebraska by A. L. Lugn, pp. 319–356. Pt. II, The Pleistocene Mammals of Nebraska by Charles Bertrand Schultz, pp. 357–393.

Lull, Richard Swann

1908.1 The Evolution of the Elephant. Amer. Journ. Sci., (4), XXV, March, pp. 169–212, text figs. 1–27, 4 charts.
Reprinted, after author's revision, in Smithson. Rept. for 1908, published 1909, pp. 641–675.

1917.1 Organic Evolution. A Text-Book. 8vo, The Macmillan Company, New York, pp. xviii+729, 30 pls., 253 text figs.

Lull, Richard Swann, and Charles Schuchert

1914.1 See Schuchert, Charles, and Richard Swann Lull.

Lund, Peter Wilhelm

1839.1 Blik paa Brasiliens Dyreverden för sidste Jordomvæltning. K. Dansk. Vidensk. Selskabs. Afhandl., VIII (1839–1841), pp. 29–144, Tab. i–xiii.
Mastodon, see pp. 117, 129, 130, 133, 136.

Lydekker, Richard

1876.1 Molar Teeth and Other Remains of Mammalia. Mem. Geol. Surv. India, Palaeont. Indica, (X), I, Pt. II, pp. 19–87, Pls. iv–x. Appendix, 1 page.
New species: *Dinotherium pentapotamiæ*, p. 72.

1876.2 Description of a Cranium of Stegodon ganesa, with Notes on the Subgenus and Allied Forms. Rec. Geol. Surv. India, IX, Pt. II, pp. 42–49.
This specimen is in the Indian Museum, Calcutta, No. A.343.

1876.3 Notes on the Fossil Mammalian Faunæ of India and Burma. Rec. Geol. Surv. India, IX, Pt. III, pp. 86–101, Appendices A, B, pp. 101–106.

1877.1 Notices of new and other Vertebrata from Indian Tertiary and Secondary Rocks. Rec. Geol. Surv. India, X, Pt. I, pp. 30–43.
Tusk of *Stegodon ganesa* from Biltari in the Nerbudda valley. *Antoletherium* Falconer: It is stated on page 33 that the original lower jaw was sent to the Indian Museum by the Asiatic Society; referred to *Dinotherium*.

1877.2 Notices of new or rare Mammals from the Siwaliks. Rec. Geol. Surv. India, X, Pt. II, pp. 76–83.
New species: *Mastodon (Trilophodon) Falconeri*, p. 83.

1878.1 Notices of Siwalik Mammals. Rec. Geol. Surv. India, XI, Pt. I, pp. 64–104.
Mastodon, *Stegodon*, and *Dinotherium* reviewed on pages 70–76.

1879.1 Further Notices of Siwalik Mammals. Rec. Geol. Surv. India, XII, Pt. I, pp. 33–52, 1 pl.
New species of *Dinotherium* (without name), p. 43; reviews the species *Dinotherium indicum*, *Mastodon pandionis*, *M. perimensis*.

1880.1 Siwalik and Narbada Proboscidia. Mem. Geol. Surv. India, Palaeont. Indica, (X), I, Pt. V, pp. 182–300, Pls. xxix–xlvi.
New species: *Dinotherium sindiense*, p. 196. Supplementary description of *Dinotherium pentapotamiæ* and *Mastodon falconeri* with type figure of the latter, 1880, Pl. xxxiii, figs. 1 and 4. Type figure of *Mastodon stegodontoides* Pilgrim, Pl. xxxix (figured as *Mastodon (Tetralophodon) latidens*), and of *Mastodon punjabiensis* Lydekker, Pl. xlii (figured as *M. (Tetralophodon) perimensis*). Dentition of the Elephantidæ. Detailed treatment of *Mastodon pandionis*, *M. latidens*, *M. perimensis*, *M. sivalensis*, *Stegodon cliftii*, *S. bombifrons*, *S. insignis*, *S. ganesa*, *Loxodon* [=*Archidiskodon*] *planifrons*, *Euelephas* [=*Elephas* (*Hypselephas*)] *hysudricus*. Excellent table of recent and fossil Proboscidea.

1881.1 Supplement to Siwalik and Narbada Proboscidia. Mem. Geol. Surv. India, Palaeont. Indica, (X), II, Pt. II, pp. 63–66.
Occurrence of *Stegodon cliftii*, *S. insignis*, or *bombifrons*, and *Elephas namadicus* in Japan.

Lydekker, Richard—Continued

1884.1 (See **1886.1**.)

1884.2 Additional Siwalik Perissodactyla and Proboscidia. Mem. Geol. Surv. India, Palaeont. Indica, (X), III, Pt. I, February, pp. xxiv+34, 5 pls., 6 text figs.

New species: *Mastodon (Trilophodon) angustidens* Cuv. var. *pulvindicus*. Note on type locality of *Mastodon pandionis*, namely, from Sind rather than the Deccan.

1884.3 Mastodon Teeth from Perim Island. Mem. Geol. Surv. India, Palaeont. Indica, (X), III, Pt. V, pp. 149–154, Pls. xvi, xvii.

Mastodon perimensis may be a specialized descendant from the stock of *M. pandionis*.

1885.1 Catalogue of the Remains of Siwalik Vertebrata contained in the Geological Department of the Indian Museum, Calcutta. Pt. I. Mammalia. 8vo, Calcutta, pp. x+116.

1885.2 Description of a Tooth of Mastodon latidens, Clift, from Borneo. Proc. Zool. Soc. London, pp. 777–779, Pl. xlviii.

[In the present Memoir made by Osborn the type of *Stegolophodon lydekkeri*.]

1886.1 Addenda to Synopsis of Siwalik & Narbada Mammalia. Mem. Geol. Surv. India, Palaeont. Indica, (X), III, pp. xi–xxiv, text figs. 1–11.

New species: *Mastodon cautleyi*.

1886.2 Catalogue of the Fossil Mammalia in the British Museum . . . Pt. IV, Containing the Order Ungulata, Suborder Proboscidea. 8vo, London, pp. vii+233, 32 text figs.

New species: *Mastodon punjabiensis*.

1886.3 On the Fossil Mammalia of Maragha in North-western Persia. Quart. Journ. Geol. Soc. London, XLII, pp. 173–176. Discussion, p. 181.

Chinese molar in British Museum (No. 29007) referred to *Elephas armeniacus* by Lydekker. Range of *E. armeniacus* similar to that of *Rhinoceros blanfordi*, i.e., from western Asia through the north of India to China.

1900.1 The Great and Small Game of India, Burma, and Tibet. 4to, Rowland Ward, Ltd., London, pp. xviii+416, 9 pls., 62 text figs.

Elephas maximus sumatranus, p. 11.

1906.1 The Albert Nyanza Elephant. Field, London, CVII, p. 1089.

Original description of living African species: *Elephas africanus albertensis*.

1907.1 The Ears as a Race-Character in the African Elephant. Proc. Zool. Soc. London, 1907, I, pp. 380–403, text figs. 105–121.

Original description of living African species: *Elephas africanus toxotis*, *E. a. selousi*, *E. a. peeli*, *E. a. cavendishi*, *E. a. orleansi*, *E. a. rothschildi* (type statuette of "Jumbo" in the British Museum (Natural History); type figures of *Elephas africanus albertensis* and *E. a. cottoni* (figured as *E. a. cyclotis*?).

1907.2 Notes on Two African Mammals. Proc. Zool. Soc. London, 1907, II, pp. 782–785, text fig. 205.

E.[lephas] a.[fricanus] cottoni.

1907.3 Game Animals of India. (Original not seen by the present author.)

Elephas maximus zeylanicus, p. 15.

1908.1 Wild Elephants in Mesopotamia. Field, CXI, Feb. 29, No. 2879, p. 366.

1911.1 Encyclopædia Britannica, Eleventh Edition, under articles: Elephant, Vol. IX, p. 259; Proboscidea, Vol. XXII, p. 405.

1914.1 The Malay Race of the Indian Elephant. Proc. Zool. Soc. London, Abstract, March 17, No. 130, p. 20.

New subspecies: *Elephas maximus hirsutus* [name only; see Lydekker, 1914.2].

1914.2 The Malay Race of the Indian Elephant, Elephas maximus hirsutus. Proc. Zool. Soc. London, 1914, I, Art. XVIII, pp. 285–288, text figs. 1–3.

This volume contains the type figure of *E. maximus hirsutus*, p. 285, fig. 1.

1916.1 Catalogue of the Ungulate Mammals in the British Museum (Natural History), V. Proboscidea (Elephants), pp. 80–91, text figs. 23–31.

Eelphas maximus, *Elephas maximus maximus*, *Elephas maximus zeylanicus*, *Elephas maximus sumatranus*, *Elephas maximus hirsutus*; also treats the subspecies of *Elephas* (*Loxodonta*) *africanus*.

Lydekker, Richard, and William Henry Flower

1891.1 See Flower, William Henry, and Richard Lydekker.

Lyell, Charles

1830–1832 Principles of Geology, I, II. 8vo, John Murray, London.

1843.1 On the Geological Position of the Mastodon giganteum and associated Fossil Remains at Bigbone Lick, Kentucky. Ann. Mag. Nat. Hist., XII, pp. 125–128.

See also Proc. Geol. Soc. London, 1843, IV, pp. 36–39; Amer. Journ. Sci., 1844, (1), XLVI, pp. 320–323.

1845.1 On the Miocene Tertiary Strata of Maryland, Virginia, and of North and South Carolina. Quart. Journ. Geol. Soc. London, I, pp. 413–429.

Molar of *Mastodon longirostris*, p. 427.

1849.1 A Second Visit to the United States of North America, I, II. 8vo, New York.

Second edition, 1850 (*fide* Hay, 1923.1, p. 30).

1855.1 A Second Visit to North America. Third edition. 8vo, John Murray, London, I, pp. xii+368; II, pp. xii–385.

Maarel, Franciscus Hendricus, van der

1932.1 Contribution to the Knowledge of the Fossil Mammalian Fauna of Java. 8vo, Amsterdam, 208 pp., 20 pls., 29 text figs., 2 maps, 26 tables.

New subfamily: *Tetralophodontinæ*. New species: *Tetralophodon bumiajuensis*, *Stegodon bondelensis*. Treats Archidiskodonta, Stegodonta. Occurrence of *Archidiskodon planifrons* in Java [probably referable to *Palæoloxodon*].

Maddren, Alfred Geddes

1905.1 Smithsonian Explorations in Alaska in 1904, in Search of Mammoth and other Fossil Remains. Smithson. Misc. Coll., XLIX, No. 1584, pp. 5–117.

1905.2 Notes on the Occurrence of Mammoth Remains in Alaska. Science, N.S., XXI, No. 541, May 12, pp. 746, 747.

Majer, István

1924.1 A technika, a tudomány és a művészet az ősléntan szolgálatában. Természettudományi Közlöny, LVI, January-February, Füz. 809.

Reprint, pp. 1–8, text figs. 1–5.

Major, Charles Immanuel Forsyth

1875–1876. Considerazioni sulla Fauna dei Mammiferi pliocenici e post-pliocenici della Toscana. Atti Soc. Toscana Sci. Nat., I, Fasc. 1, pp. 7–40, and Fasc. 3, pp. 223–245. Pisa.

1883.1 Die Tyrrhenis. Kosmos, XIII, Jahrg. VII, p. 1–17.

New species: *Elephas Lamarmoræ*.

Makiyama, Jirô

1924.1 Chikyû—The Globe, I. (Original in Japanese and not available to the present author. Reference, *fide* Matsumoto, 1929.1).

New subspecies: *Elephas namadicus naumanni* and *Elephas namadicus namadi*, p. 381, Pl. viii.

1924.2 Notes on a Fossil Elephant from Sahamma, Tôtômi. Mem. College Sci. Kyoto Imp. Univ., (B), I, No. 2, Art. III, June 30, pp. 255–264, Pls. xii–xvi.

English description of *Elephas namadicus naumanni* and *Elephas namadicus namadi* [see Makiyama, 1924.1 for first description in Japanese].

Marschall, Augusto de

1873.1 Nomenclator Zoologicus. 8vo, Vindobonae, pp. iv+482.

Mammalia, pp. 1–13.

Marsh, Othniel Charles

1867.1 Discovery of additional Mastodon remains at Cohoes, N. Y. Amer. Journ. Sci., (2), XLIII, pp. 115, 116.

1874.1 Small Size of the Brain in Tertiary Mammals. Amer. Journ. Sci., (3), VIII, No. 43, pp. 66, 67.

Mastodon from the Pliocene of the western United States has larger brain than *Brontotherium*, but not equal to that of existing proboscideans.

1875.1 Mastodon of Otisville, Orange County, N. Y. Amer. Journ. Sci., (3), IX, No. 54, p. 483.

Supports proposal and [illegible] Fig 129 of [illegible] of mounted skeleton in the [illegible] Museum of Yale University [Yale Mus. 12600]. See Marsh, 1892.1

1877.1 Introduction and Succession of Vertebrate Life in America. Nature, XVI, pp. 448–450, 470–472, 489–491; also Amer. Journ. Sci., (3), XIV, pp. 337–378.

Mastodon, *Elephas primigenius*.

1879.1 History and Methods of Palæontological Discovery. Nature, XX, pp. 491–499, 515–521; also Amer. Journ. Sci., (3), XVIII, pp. 323–359.

Cites discovery of skeleton of fossil el[illegible] at Tonna, near Gotha, in Germany, and decision by Medical Faculty [illegible] it was a freak of nature as an instance of the power of the *lusus naturæ* [illegible]

Marsh, Othniel Charles—Continued

1885.1 The Gigantic Mammals of the Order Dinocerata. 5th Ann. Rept. U. S. Geol. Surv., 1883–84, pp. 243–302, text figs. 36–137.

Brain growth of *Mastodon americanus*, fig. 107; *Elephas indicus*, fig. 110.

1892.1 Restoration of Mastodon Americanus, Cuvier. Amer. Journ. Sci., (3), XLIV, p. 350, Pl. viii.

This superb skeleton was exhumed May 7, 1875, at Otisville, Orange Co., N. Y., "seventy-five miles from New York and within a mile and a half of the Erie Railroad. The bones were found on and in clay beneath a deep bed of muck, and are in excellent state of preservation." [Yale Mus. 12600. Compare Marsh, 1875.1, also figure 129 of the present Memoir for view of cranium.]

1896.1 Vertebrate Fossils. In "Geology of the Denver Basin in Colorado," by Samuel Franklin Emmons, Whitman Cross, and George Homans Eldridge. Monographs U. S. Geol. Surv., XXVII, Chap. VII, Sec. II, pp. 473–560, Pls. xxi–xxxi, text figs. 23–102.

Mastodon obscurus cited, p. 527. Restoration of *Mastodon americanus*, Pl. xxi.

Martin, Johann Karl Ludwig

1884.1 Ueberreste vorweltlicher Proboscidier von Java und Banka. Samml. Geol. Reichsmus. Leiden. Beiträge Geol. Ost-Asiens u. Australiens, (1), IV, Heft I, pp. 1–24, Tab. i.

This appears also in Jaarb. Mijnw. N.O.I., Wetensch. Ged., XIII, pp. 285–308, Tab. i. Verhandeling No. 20, der Pal. van Nederl.-Indië.

1887.1 Fossile Säugethierreste von Java und Japan. Samml. Geol. Reichsmus. Leiden. Beiträge Geol. Ost-Asiens u. Australiens, (1), IV, Heft II, pp. 25–69, Tab. ii–ix.

This appears also in Jaarb. Mijnw. N.O.I., Wetensch. Ged., XVI, pp. 1–45, Tab. ii-ix. Verhandeling No. 21, der Pal. van Nederl.-Indië.
New species: *Stegodon trigonocephalus*, p. 36.

1888.1 Neue Wirbelthierreste vom Pati-Ajam auf Java. Samml. Geol. Reichsmus. Leiden, (1), IV, Heft III, pp. 87–116, Tab. xi, xii.

1890.1 Ueber Neue Stegodon-Reste aus Java. Verh. Kon. Akad. Wetensch. Afdeel. Natuurk., XXVIII, pp. 1–13, Tab. i–iii. Amsterdam.

New species: *Stegodon Airâwana*.

Mather, William Williams

1838.1 First Annual Report on the Geological Survey of the State of Ohio. Columbus, 154 pp., frontispiece, and 4 figs.

This embodies the Report of C. Briggs, Jr., Fourth Assistant Geologist, pp. 73–109, in which he mentions the discovery of fossil remains in Jackson County, Ohio, on pp. 96, 97 (see fig. 3 of frontispiece, cross-section of type locality); subsequently (see Mather, 1838.3) these remains were described and figured under the name *Elephas jacksoni*.

1838.2 First Annual Report on the Geological Survey of the State of Ohio. Amer. Journ. Sci., (1), XXXIV, pp. 347–362.

This is a review of the above report, quoting portions of the report by C. Briggs, Jr. See page 358 for description of *Elephas jacksoni*, but without name.

1838.3 Remarks in addition to and explanation of the Review of the Report of the Geological Survey of Ohio—in a letter to the Editor. Amer. Journ. Sci., (1), XXXIV, pp. 362–364, 3 text figs.

New species: *Elephas jacksoni*, with figure.

Matschie, Paul

1900.1 Über geographische Abarten des afrikanischen Elefanten. Sitz.-Ber. Ges. naturf. Freunde Berlin, No. 8, pp. 189–197.

New subspecies of living African elephants: *Elephas capensis cyclotis* or *E.* (*Loxodonta*) *cyclotis*, *E.* (*Loxodonta*) *oxyotis*, *E.* (*Loxodonta*) *knochenhaueri*.

Matsumoto, Hikoshichirô

1915.1 Scientific Gazette, Tokyo, III, No. 5, pp. 308–315. Published in Japanese. (Original not available.)

New species: *Elephas auroræ*.

1915.2 On Some Fossil Mammals from Sze-chuan, China. Sci. Rept. Tôhoku Imp. Univ., (2), Geology, III, No. 1, pp. 1–28, Pls. i–x, text figs. 1–4.

Stegodon fauna of Sze-chuan resembles that of India and Java, probably nearer to that of the Siwaliks than to that of Narbada and of Java—hence Pliocene.

1915.3 On Some Fossil Mammals from Tsukinoki, Ugo. Sci. Rept. Tôhoku Imp. Univ., (2), Geology, III, No. 1, pp. 39–49, Pls. i–iv.

Elephas namadicus (?).

1916.1 List of Japanese Mammalian Fossil Beds. Journ. Geol. Soc. Tokyo, XXIII, No. 275, pp. 291–299. Published in Japanese.

Supplementary description of *Elephas auroræ*, p. 294.

1918.1 On a New Archetypal Fossil Elephant from Mt. Tomuro, Kaga. Sci. Rept. Tôhoku Imp. Univ., (2), Geology, III, No. 2, pp. 51–60, Pl. xx, text figs. 1–3.

Supplementary description in English of *Elephas auroræ*.

1922.1 Revision of Palæomastodon and Mœritherium. Palæomastodon intermedius, and Phiomia osborni, New Species. Amer. Mus. Novitates, No. 51, Nov. 21, 6 pp., 3 text figs.

New species: *Palæomastodon intermedius*, *Phiomia osborni*. Note by Osborn comparing *Palæomastodon* and *Phiomia*.

1923.1 A Contribution to the Knowledge of Mœritherium. Bull. Amer. Mus. Nat. Hist., XLVIII, Art. IV, pp. 97–140, text figs. 1–11. (Issued Sept. 21.)

Phylogeny of the species.

1924.1 A Revision of Palæomastodon dividing it into Two Genera, and with Descriptions of Two New Species. Bull. Amer. Mus. Nat. Hist., L, Art. I, pp. 1–58, text figs. 1–48. (Issued July 2.)

Supplementary description of *Palæomastodon intermedius* and *Phiomia osborni*. Transfers *Palæomastodon minor* to the genus *Phiomia*.

1924.2 Preliminary Note on Fossil Elephants in Japan. Journ. Geol. Soc. Tokyo, XXXI, No. 371, Sept. 20, pp. 255–272. Published in Japanese.

New genus: *Parastegodon*, pp. 256, 257. New subgenus: *Palæoloxodon*, pp. 257, 260. New species: *Euelephas protomammonteus*, p. 262, *Loxodonta* (*Palæoloxodon*) *tokunagai*, p. 267.

1924.3 Preliminary Notes on the Species of Stegodon in Japan. Journ. Geol. Soc. Tokyo, XXXI, No. 373, Nov. 20, pp. 323–340. Published in Japanese.

New genus: *Prostegodon* Matsumoto, first description, pp. 324–327 [name only appeared in Osborn (1923.601, p. 2); see also Matsumoto, 1926.1, for English text on this genus]. New subspecies: *Stegodon orientalis shodoënsis*.

1924.4 Preliminary Notes on Two New Species of Fossil Mastodon from Japan. Journ. Geol. Soc. Tokyo, XXXI, No. 375, Dec. 20, pp. 395–414. Published in Japanese.

New species: *Hemimastodon* [=*Serridentinus*] *annectens*, pp. 401, 405; *Trilophodon sendaicus*, pp. 402, 408.

1926.1 On Two New Mastodonts and An Archetypal Stegodont of Japan. Sci. Rept. Tôhoku Imp. Univ., (2), Geology, X, No. 1, pp. 1–11, Pls. i–v.

Supplementary description in English of *Hemimastodon* [=*Serridentinus*] *annectens*, *Trilophodon sendaicus*, and *Prostegodon*, also *Parastegodon*, genotype *Elephas auroræ*.

1926.2 On the Archetypal Mammoths from the Province of Kazusa. Sci. Rept. Tôhoku Imp. Univ., (2), Geology, X, No. 2, pp. 43–50, Pls. xviii–xxiv.

New subspecies: *Parelephas protomammonteus proximus*. Further description of *Parelephas protomammonteus* (Matsumoto) *typicus*, [first named by Matsumoto (1924.2) *Euelephas protomammonteus*].

1927.1 On a New Fossil Race of the Asiatic Elephant in Japan. Sci. Rept. Tôhoku Imp. Univ., (2), Geology, X, No. 3, pp. 57, 58. Pls. xxvii, xxviii.

New subspecies: *Elephas indicus Buski*.

1927.2 On Leith-Adamsia Siwalikiensis, a New Generic and Specific Name of Archetypal Elephants. Japanese Journ. Geol. and Geog., V, No. 4, Art. XII, 1 page.

New genus: *Leith-Adamsia*. New species: *Leith-Adamsia siwalikiensis*.

1929.1 On Loxodonta (Palæoloxodon) namadica (Falconer and Cautley) in Japan. Sci. Rept. Tôhoku Imp. Univ., (2), Geology, XIII, No. 1, pp. 1–5, Pls. i–vi.

New subspecies: *Loxodonta* (*Palæoloxodon*) *namadica* (*Yabei*).

1929.2 On Loxodonta (Palæoloxodon) tokunagai, with Remarks on the Descent of Loxodontine Elephants. Sci. Rept. Tôhoku Imp. Univ., (2), Geology, XIII, No. 1, pp. 7–11, Pl. vii.

New subspecies: *Loxodonta* (*Palæoloxodon*) *Tokunagai junior* mut.

1929.3 On Parastegodon Matsumoto and Its Bearing on the Descent of Earlier Elephants. Sci. Rept. Tôhoku Imp. Univ., (2), Geology, XIII, No. 1, pp. 13–15, Pl. viii.

Parastegodon (description in English), genotype, *Elephas auroræ*. Rise of *Parastegodon*. Refers *Elephas planifrons* and *Stegodon mindanensis* to *Parastegodon*.

Matthew, William Diller

1899.1 A Provisional Classification of the Fresh-water Tertiary of the West. Bull. Amer. Mus. Nat. Hist., XII, Art. III, March 31, pp. 19–75.

Revised list of mammal faunæ of American Tertiary formations with details of occurrence and critical estimate of the validity and importance of species. Correlation based upon these data.
Proboscidea: (Loup Fork), p. 68; (Blanco), p. 75.

1902.1 List of the Pleistocene Fauna from Hay Springs, Nebraska. Bull. Amer. Mus. Nat. Hist., XVI, Art. XXIV, Sept. 25, pp. 317–322.

Elephas primigenius columbi (Hay Springs), p. 318; *E. prim.* (?) *columbi*, Silver Lake, Ore., p. 320.

1907.1 The Skeleton of the Columbian Mammoth. Amer. Mus. Journ., VII, No. 1, pp. 5, 6.

Unsigned and of doubtful authorship.

1908.1 Mammalian Migrations between Europe and North America. Amer. Journ. Sci., (4), XXV, No. 145, pp. 68–70.

1909.1 The Science-History of the Universe. Zoölogy. Small 8vo, Current Literature Publishing Co., New York, VI, 194 pp. (Series published in ten volumes, Francis Rolt-Wheeler, Managing Editor.)

Brief statement regarding elephants, mastodons and mammoths, with ancestry, etc.

1910.1 Notes and Literature—Schlosser on Fayûm Mammals. Amer. Naturalist, XLIV, pp. 700–703.

Relationship of Hyracoidea to Proboscidea through *Mœritherium* must be limited to common derivation from Condylarth ancestry.

1912.1 African Mammals. Bull. Geol. Soc. Amer., XXIII, pp. 156–162.

Supposed ancestors of the Proboscidea, *Mœritherium* and *Palæomastodon*. No doubt about the position of *Palæomastodon*, but that of *Mœritherium* is uncertain; generally regarded as ancestral to *Palæomastodon*, a point which Osborn regards as open to serious question. Conclusion generally drawn that the Proboscidea evolved in the Ethiopian region, but this view is not in accord with the writer's (Matthew's) opinion. Migration and dispersal possibly were first Ethiopian, then Asiatic, a reversal of the normal course.

1915.1 News Notes. The Fulton Mastodon. Amer. Mus. Journ., XV, No. 7, p. 373. (Unsigned.)

1915.2 Mammoths and Mastodons. A Guide to the Collections of Fossil Proboscideans in the American Museum of Natural History. Guide Leaflet Series Amer. Mus. Nat. Hist., No. 43, November, 26 pp., 11 text figs.

1915.3 Climate and Evolution. Ann. New York Acad. Sci., XXIV, pp. 171–318, text figs. 1–33.

1915.4 Problems of American Geology. Chapter VII, The Tertiary Sedimentary Record and its Problems. 8vo, Yale University Press, New Haven, pp. 377–478, text figs. 1–40, map.

This volume is in collaboration with six other authors.
Discussion of the Tertiary sedimentary formations of the Cordilleran region, their character and origin. Review of the fossil record as contained therein showing the evolution of the Tertiary faunas. Evolution of Proboscideans, pp. 461–463.

1917.1 News Notes. A Pliocene Mastodon Skeleton. Amer. Mus. Journ., XVII, No. 2, p. 149. (Unsigned.)

1917.2 Prehistoric Animal Life. The Mentor, Dept. Nat. Hist., V, No. 13, Aug. 15.

Siberian Mammoth or Hairy Elephant.

1918.1 Contributions to the Snake Creek Fauna. With Notes upon the Pleistocene of Western Nebraska—American Museum Expedition of 1916. Bull. Amer. Mus. Nat. Hist., XXXVIII, Art. VII, April 18, pp. 183–229, Pls. IV–X, text figs. 1–20.

Zygolophodon aff. *serridens* (Cope). *Trilophodon* (=*Gomphotherium*) sp. Selection of *M. tapiroides* as the type of *Zygolophodon* Vacek, p. 200.

1918.2 Generic Nomenclature of the Proboscidea. (Abstract.) Bull. Geol. Soc. Amer., XXIX, p. 141.

Suggests submission of certain names as *nomina conservanda* to the Committee of International Zoological Congress with endorsement of Paleontological Society.

1929.1 Critical Observations Upon Siwalik Mammals. (Exclusive of Proboscidea.) Bull. Amer. Mus. Nat. Hist., LVI, Art. VII, pp. 437–560, text figs. 1–55. (Issued Feb. 9.)

Proboscidea, pp. 448 (faunal list), 450 (*Dinotherium*), 453 (faunal list), 455, 457 (review of collection in Indian Museum).

1930.1 A Pliocene Mastodon Skull from California, Pliomastodon vexillarius, N. Sp. Bull. Dept. Geol. Univ. Calif., XIX, No. 16, pp. 335–348, Pls. XLI–XLIV, text figs. 1, 2.

New species: *Pliomastodon vexillarius*.

Matthew, William Diller, and Harold James Cook

1909.1 A Pliocene Fauna from Western Nebraska. Bull. Amer. Mus. Nat. Hist., XXVI, Art. XXVII, Sept. 3, pp. 361–415, text figs. 1–27.

First description of the Snake Creek fauna, regarded as Lower Pliocene.

Matthew, William Diller, and Edward Drinker Cope

1915.1 Hitherto Unpublished Plates of Tertiary Mammalia and Permian Vertebrata. Prepared under direction of Edward Drinker Cope for U. S. Geological Survey of the Territories with Descriptions of Plates by William Diller Matthew. Published, with the Coöperation of the U. S. Geological Survey, by The American Museum of Natural History, Monograph Series No. 2, Pls. I–CLIV.

New species: *Mastodon "ligoniferus."* Refigures type of *Tetralophodon campester* Cope.

Matthew, William Diller, and Walter Granger

1923.1 New Fossil Mammals from the Pliocene of Sze-Chuan, China. Bull. Amer. Mus. Nat. Hist., XLVIII, Art. XVII, Dec. 10, pp. 563–598, text figs. 1–27.

Review of *Stegodon orientalis*.

Matthew, William Diller, and Henry Fairfield Osborn

1909.1 See Osborn, Henry Fairfield, 1909.321.

Maydon, H. C.

1932.1 Big Game Shooting in Africa. The Lonsdale Library, XIV, 445 pp., 141 pls. 8vo, London.

This volume is in collaboration with twenty-one other authors.

Mayet, Lucien

1908.1 Étude des Mammifères Miocènes des Sables de l'Orléanais et des Faluns de la Touraine. Ann. Univ. Lyon, Nouvelle Série, I. Sciences, Médicine. Fasc. 24, 336 pp., 12 pls., 100 text figs.

The Sables de l'Orléanais yields three species of *Mastodon*, *M. angustidens*, *M. turicensis*, *M. pyrenaicus*; and one species of *Dinotherium*, *D. cuvieri*.

1909.1 Étude Sommaire des Mammifères Fossiles des Faluns de la Touraine. Ann. Univ. Lyon, Nouvelle Série, I. Sciences, Médicine. Fasc. 26, 72 pp., 30 text figs.

1920.1 Découverte d'un squelette d'Elephas planifrons Falconer dans les sables de Chagny, à Bellecroix près Chagny (Saône-et-Loire). Note de MM. Lucien Mayet, Pierre Nugue et J. Dareste de la Chavanne. Compt. Rend. Acad. Sci., CLXXI, pp. 308–311. Paris.

1922.1 La faune villafranchienne des sables de Chagny (Saône-et-Loire). Compt. Rend. Acad. Sci., CLXXIV, pp. 1254–1256. Paris.

Mayet, Lucien, Charles Depéret, and Frédéric Roman

1923.1 See Depéret, Charles, Lucien Mayet, and Frédéric Roman.

McGrew, Paul O., and Ruben Arthur Stirton

1935.1 See Stirton, Ruben Arthur, and Paul O. McGrew.

Mercier, ———, Georges Léopold Chrétien Frédéric Dagobert Cuvier, and Charles Léopold Laurillard

1850-1856. See Cuvier, Georges Léopold Chrétien Frédéric Dagobert, Charles Léopold Laurillard, and ———Mercier.

Merck, Johann Heinrich

1782.1 Lettre a Monsieur de Cruse . . . Sur les Os Fossiles d'Éléphans et de Rhinocéros qui se trouvent dans le Pays de Hesse-Darmstadt. Dated Darmstadt, 31 August, 1782, 24 pp., 2 pls. Small 4to.

1784.1 Seconde Lettre a Monsieur de Cruse . . . Sur les Os Fossiles d'Éléphans et de Rhinocéros qui se trouvent en Allemagne et Particulierement dans le Pays de Hesse-Darmstadt. Dated Darmstadt, 15 May, 1784, 27 pp., 4 pls. Small 4to.

1786.1 Troisième Lettre sur les Os Fossiles d'Éléphans et de Rhinocéros qui se trouvent en Allemagne et particulierement dans le Pays de Hesse-Darmstadt addressée a Monsieur Forster. Dated Darmstadt, 1 May, 1786, 30 pp., 3 pls. Small 4to.

Merian, Peter

1852.1 Ueber das Vorkommen des Dinotherium giganteum im Delsberger Thal des Bernerischen Jura. Bericht ueber die Verhandlungen der Naturforschenden Gesellschaft in Basel, X, pp. 144–147.

Dinotherium from Delsberg Valley in the Bernese Jura, p. 144.

Merriam, John Campbell

1911.1 Tertiary Mammal Beds of Virgin Valley and Thousand Creek in Northwestern Nevada. Bull. Dept. Geol. Univ. Calif., VI, No. 11, pp. 199–304, text figs. 1–80, Pls. xxxii, xxxiii. (Issued Sept. 16.)

Proboscidea: *Mastodon* (*Tetrabelodon*? sp.) on pp. 271, 272, Pl. xxxiii, text-figs. 46 and 47.

1915.1 Tertiary Vertebrate Faunas of the North Coalinga Region of California. A Contribution to the Study of Palaeontologic Correlation in the Great Basin and Pacific Coast Provinces. Trans. Amer. Phil. Soc., XXII, N.S., Art. III, pp. 191–234, text figs. 1–49b.

Proboscidea, p. 203.

1916.1 Tertiary Vertebrate Fauna from the Cedar Mountain Region of Western Nevada. Bull. Dept. Geol. Univ. Calif., IX, No. 13, pp. 161–198, text figs. 1–48, Pl. viii (outline map). (Issued Feb. 23.)

1916.2 Mammalian Remains from a Late Tertiary Formation at Ironside, Oregon. Bull. Dept. Geol. Univ. Calif., X, No. 9, pp. 129–135, text figs. 1–3. (Issued Dec. 23.)

Tetrabelodon? sp., p. 134, and fig. 3.

Merrill, George Perkins

1907.1 Catalogue of the Type and Figured Specimens of Fossils, Minerals, Rocks, and Ores in the Department of Geology, United States National Museum. Pt. II. Fossil Vertebrates; Fossil Plants; Minerals, Rocks, and Ores. Bull. U. S. Nat. Mus., No. 53, 370 pp.

Types: *Elephas imperator*, *Mastodon floridanus*, *M. mirificus*, *M. productus*; referred specimens, *E. columbi*, *M. andium*, *M. obscurus*. Tarboro molar regarded by Merrill (p. 45) as the type of Leidy's *Mastodon obscurus* [=*Ocalientinus* (*Serridentinus*) *obliquidens* ref. of present Memoir].

Meyer, Hermann von [Christian Erich Hermann von Meyer]

1831.1 [Note on Dinotherium giganteum and D. bavaricum.] Neues Jahrb. Min., pp. 296, 297.

New species: *Deinotherium Bavaricum*.

1831.2 Ueber Mastodon arvernensis bei Eppelsheim. Nova Acta Acad. Leop. Carol., XV, Pt. II, pp. 113–124.

1832.1 Beiträge zur Petrefaktenkunde . . . Fossile Säugethiere. Nova Acta Acad. Leop. Carol., XVI, Pt. II, pp. 485–516, Tab. xxxiv–xxxvi.

Dinotherium giganteum and *D. bavaricum*, p. 487; *D. bavaricum* is one quarter smaller than *D. giganteum*.

1832.2 Palaeologica zur Geschichte der Erde und ihrer Geschöpfe. 8vo, Frankfurt a.M., 560 pp.

Dinotherium maximum (Kaup MS.), p. 78; *Mammut Sibiricum*, p. 64.

1839.1 Die fossilen Säugethiere, Reptilien, und Vögel aus den Molasse-Gebilden der Schweitz. Neues Jahrb. Min., pp. 1–9.

Apparently first use of the form *Mastodon turicensis*, p. 2.

1840.1 Über Uhde's sammlung mexikanischer Antiquitäten, Mineralien und Petrefakten. Neues Jahrb. Min., pp. 576–587.

1865.1 Ueber die fossilen Reste von Wirbelthieren . . . Palæontogr. XV, pp. 1–40, Taf. i–viii (1865–1868).

1867.1 Studien über das Genus Mastodon. Palaeontogr., XVII, pp. 1–72, Taf. i–ix (1867–1870).

New species: *Mastodon virgatidens*, p. 61. *Mastodon humboldtii* Cuv. (Taf. vi); [chosen by Cope as type figure of *Dibelodon tropicus*, 1884].

Meyer, Hermann von, and Heinrich Robert Göppert

1848.1 Index palaeontologicus in Bronn's Handbuch einer Gescichte der Natur, III, Abth. 1, Erste Hälfte, pp. viii+lxxxiv+775.

New genus: *Cheirolites*, p. 286. Cites *Mastodon arborense* Koch and *Dinotherium angustidens* Koch, p. 705; *Elephas*, pp. 454, 455; Mastodons, pp. 705–707.

Miller, Hugh

1852.1 The Foot-Prints of the Creator: or, the Asterolepis of Stromness . . . With a Memoir of the Author, by Louis Agassiz. 8vo, Gould and Lincoln, Boston, pp. xlii+337, 58 text figs.

Dinotherium possibly an aquatic quadruped, p. 317. The present author (Osborn) had access to the 1852 edition only.

Moodie, Roy Lee

1930.1 The Ancient Life of Yuma County, Arizona. Sci. Monthly, XXXI, November, pp. 401–407, text figs. 1a, 1b, 2–9.

Archidiskodon imperator from Rancho La Brea, as mounted in the Los Angeles Museum; fragments of what seem to be portions of occipital region of a small Mastodon.

Moreno, Francisco Josué Pascasio

1888.1 Informe Preliminar de los progresos del Museo La Plata, durante el primer semestre de 1888. 8vo, Buenos Aires, 35 pp.

New species: *Mastodon bonaerensis*, pp. 17, 18.

According to the Supplement (1933) of the Catalogue of the Library, British Museum (Natural History), this is: "Marked as having formed part of the *Boletino del Museo La Plata*, but no such publication seems ever to have appeared."

Morren, Charles François Antoine

1834.1 Mémoire sur les Ossemens Fossiles D'Éléphans trouvés en Belgique. 8vo, Gand, 23 pp., 2 pls.

New species: *Elephas macrorynchus*.

Mossom, Stuart, and Charles Wythe Cooke

1929.1 See Cooke, Charles Wythe, and Stuart Mossom.

Murchison, Charles

1867.1 and **1868.1** See Falconer, Hugh.

Murray, James Augustus Henry

1891, 1908 A New English Dictionary on Historical Principles Founded mainly on the Materials collected by the Philological Society. Edited by Sir James A. H. Murray. Oxford.

Elephant (1891); Mammoth, Mastodon (1908). Mammoth: "The word is of obscure origin; the alleged Tartar word *mama* 'earth' (usually cited as the etymon) is not known to exist."

Muybridge, Eadweard

1899.1 Animals in Motion. An Electro-Photographic Investigation of Consecutive Phases of Animal Progressive Movements. London, pp. x–264.

Proboscidea, pp. 57, 99, and 101.

Nasmyth, Alexander

1842.1 On the minute Structure of the Tusks of extinct Mastodontoid Animals. Proc. Geol. Soc. London, III, Pt. II, No. 91, pp. 775–780.

Reviews the species *Tetracaulodon godmani*, *T. kochii*, *T. tapiroides*, also *Missourium*, of Koch's collection.

Naumann, Edmund

1881.1 Ueber Japanische Elephanten der Vorzeit. Palaeontogr., XXVIII, pp. 1–39, Taf. i–vii.

Comments on *Stegodon cliftii*, *S. insignis*, *Elephas namadicus*, *and Elephas primigenius*.

1887.1 Fossile Elephantenreste von Mindanáo, Sumátra und Malakka. Abh. Ber. k. Zool.-Anthrop.-Ethnog. Mus. Dresden, No. 6, pp. 1–11, text figs. 1–6.

New species: *Stegodon trigonocephalus* [*mindanensis*].

1890.1 Stegodon Mindanensis, eine neue Art von Uebergangs-Mastodonten. Zeitschr. deutsch. geol. Ges., XLII, Heft I, pp. 166–169.

New species: *Stegodon mindanensis*.

Nesti, Filippo

1808.1 Di Alcune ossa Fossili di Mammiferi che s'incontrano nel Valdarno. Ann. Mus. Imp. Fis. Stor. Nat. Firenze, I, 18 pp. 2 Tav.

First description (without name) of *Elephas meridionalis*.

1825.1 Sulla nuova specie di elefante fossile del Valdarno all'Illustrissimo sig. Dott. Prof. Ottaviano Targioni Tozzetti. (Lettere sopra alcune ossa fossili del Valdarno non per anco descritte.) Nuov. Giorn. Lett., XI, No. 24, pp. 195–216, Tav. i.

New species: *El.* [*Elephas*] *meridionalis;* Nesti suggests, however, three other names (*Elephans Valdarnensis*, *E. Etruscus*, *E. Italicus*), but chose *meridionalis* because of the southern or temperate climate in which this species lived.

Neuville, Henri

1919.1 De l'extinction du Mammouth. L'Anthrop., XXIX, July, pp. 193–212, text figs. 1–3. Paris.

Translation by Gerrit S. Miller, Jr., "On the Extinction of the Mammouth," Smithson. Rept. for 1919 (published 1921), pp. 327–338, Pls. i–iii. Washington, D. C.

Newton, Edwin Tulley

1890.1 On some New Mammals from the Red and Norwich Crags. Quart. Journ. Geol. Soc. London, XLVI, pp. 444–453, Pl. xviii.

1890.2 Tables of Fossils. Section I: Fauna and Flora of the Land, Lakes, and Rivers. Table I: Vertebrata. In Clement Reid's "The Pliocene Deposits of Britain," Appendix I, pp. 225–228.

Newton, Richard Bullen

1914.1 See Oswald, Felix, Charles William Andrews, and Richard Bullen Newton.

Nicolucci, Giustiniano

1882.1 Su gli Elefanti fossili della Valle del Liri. Mem. Soc. ital. Sci., Congress XL, (III), IV, No. 5, 16 pp., 2 Tav. Napoli.

Euelephas primigenius, p. 5, and *Loxodon meridionalis*, p. 12, Tav. I; *Euelephas antiquus*, p. 8, Tav. II.

Niezabitowski, Edward Lubicz

1914.1 A) Słoń Mamut (Elephas Primigenius Blum). Wykopaliska Staruńskie, Muzeum Imienia Dzieduszyckich we Lwowie, XV, pp. 95–184.

Noack, Th.

1906.1 Eine Zwerg-form des afrikanischen Elefanten. Zool. Anz., XXIX, pp. 631–633. Leipzig.

Type description of *Elephas africanus pumilio:* [see Hornaday, 1905, for type figure (photograph of the animal in life); type now in The American Museum of Natural History].

Nomenclature

1910–1916 Opinions Rendered by the International Commission on Zoological Nomenclature. 8vo, Smithson. Instn. Publ., Washington, D. C.

Opinions Nos. 1 to 67 inclusive.

1916.1 The International Rules of Zoological Nomenclature. With Appendix and Summaries of Opinions No. 1 to No. 56. Extract Proc. 9th Internat. Zool. Cong., Monaco, 1913. Pub. T. O. Smallwood, Washington, D. C., 30 pp. September, 1916.

The above is an amplification (in mimeographed form) of the rules adopted by the successive International Congresses held at Berlin in 1901 (Proceedings published 1902), at Boston in 1907 (Proceedings published 1912), and at Monaco in 1913 (Proceedings published 1914), and constitutes the First Impression. The Second Impression is dated September, 1916, and contains eleven additional Opinions, namely, Nos. 57 to 67 inc., of which Nos. 58 to 67 were copied from the publications of the Smithsonian Institution.

Nordenskiöld, Erland

1903.1 Über die Säugetierfossilien des Tarijatals, Südamerika. I. Mastodon Andium Cuv. K. svenska Vetensk. Akad. Handl., XXXVII, No. 4, pp. 1–30, Taf. I–VI. Stockholm.

Oken, Lorenz

1816.1 Lehrbuch der Naturgeschichte, Theil III, Abth. 2. Leipzig and Jena. (Original not seen by the present author.)

Apparently the first use of the form *Mastodon* for Cuvier's Mastodonte, p. 789.

Orbigny, Alcide D'

1842.1 See D'Orbigny, Alcide.

Osborn, Henry Fairfield

1892.67 Fossil Mammals of the Wahsatch and Wind River Beds. Collection of 1891. Bull. Amer. Mus. Nat. Hist., IV, Art. XI, Oct. 20, pp. 81–147, Pl. IV, text figs. 1–19. (With Jacob L. Wortman.)

Principles of phylogeny.

1894.91 From the Greeks to Darwin. An Outline of the Development of the Evolution Idea. 8vo, The Macmillan Company, New York, pp. x+259. (Second edition in 1929, 8vo, Charles Scribner's Sons, New York, pp. xvi+398).

Quoted in present Memoir (p. 6).

1894.92 On Certain Principles of Progressively Adaptive Variation Observed in Fossil Series. Rept. Brit. Assoc. Adv. Sci., 1894, p. 693 (title only). Nature, L, No. 1296, Aug. 30, p. 435.

1900.181 The Angulation of the Limbs of Proboscidia, Dinocerata, and Other Quadrupeds in Adaptation to Weight. Amer. Naturalist, XXXIV, No. 398, February, pp. 89–94, text figs. 1–7.

1900.182 The Geological and Faunal Relations of Europe and America during the Tertiary Period and the Theory of the Successive Invasions of an African Fauna. Science, N.S., XI, No. 276, April 13, pp. 561–574, Charts I–V.

Theory of the Ethiopian region or South Africa as a great center of independent evolution and as the source of successive northward migrations of mammals, some of which ultimately reached even the extremity of South America—referring to the Mastodons, p. 8.

1900.187 Correlation Between Tertiary Mammal Horizons of Europe and America. Ann. New York Acad. Sci., XIII, No. 1, July 21, pp. 1–72.

Theory of successive invasions of an African fauna into Europe, p. 50, also of Africa as the center of origin of the Proboscidea, Sirenia, etc., p. 57.

1900.192 Phylogeny of the Rhinoceroses of Europe. Bull. Amer. Mus. Nat. Hist., XIII, Art. XIX, Dec. 11, pp. 229–267, text figs. 1–16

Principles of phylogeny.

1902.208 The Four Phyla of Oligocene Titanotheres. Bull Amer. Mus. Nat. Hist., XVI, Art. VIII, Feb. 18, pp. 91–109, text figs. 1–13.

Principles of phylogeny.

1903.224a Evolution of the Proboscidea in North America. Science, N.S., XVII, No. 424, Feb. 13, p. 249.

"From the oldest certainly known form, *Palæomastodon* of Egypt, through the Lower Miocene *M. angustidens* of Europe, the Proboscidea migrated to America."

1905.266 Recent Zoopaleontology. [Abstract.] Science, N.S., XXI, No. 530, Feb. 24, pp. 315, 316.

African origin of the mastodonts and elephants and course of migration to North America; further evidence of the polyphyletic evolution of the elephants, horses, rhinoceroses, camels, and titanotheres.

1905.267 Ten Years' Progress in the Mammalian Palæontology of North America. Compt. Rend. 6me Congrès intern. de Zoologie, Session de Berne, 1904, May 25, 1905, pp. 86–113, Pls. I–XV, text figs. 1–7. Amer. Geologist, XXXVI, October, 1905, pp. 199–229.

Phylogeny and correlation.

1905.270 Recent Vertebrate Paleontology. Fossil Mammals of Mexico. Science, N.S., XXI, No. 546, June 16, pp. 931, 932.

Elephas columbi in National Museum. Fine skull and tusks of *Elephas imperator*, collection of Geological Survey of Mexico

1907.295 A Mounted Skeleton of the Columbian Mammoth (Elephas columbi). Bull. Amer. Mus. Nat. Hist., XXIII, Art. XII, Mar. 30, pp. 255–257, text fig. 1.

This skeleton was subsequently made the type of *Elephas jeffersoni* by Osborn (see Osborn, 1922.555).

1907.299 A Mastodon "At Home." The Evening Post, New York, Saturday, Aug. 3, p. 2.

1907.302 Hunting the Ancestral Elephant in the Fayûm Desert. Discoveries of the Recent African Expedition of The American Museum of Natural History. The Century Magazine, LXXIV, No. 6, October, pp. 815–835.

Abstracts: Nature, LXXVI, No. 1981, Oct. 17, p. 622, "Hunting the Two Million Year Old Elephant," Illus. London News, Supplement, CXXXII, No. 3594, Mar. 7, 1908.

Mæritherium, *Palæomastodon*.

1907.303 Evolution as it Appears to the Paleontologist. Science N. S., XXVI, No. 674, Nov. 29, pp. 744–749.

First use of the word "rectigradation" with definition, p. 747.

1909.321 Cenozoic Mammal Horizons of Western North America. With Faunal Lists of the Tertiary Mammalia of the West by William Diller Matthew. Bull. 361, U. S. Geol. Surv., pp. 1–138, text figs. 1–15, 1 map.

Proboscidea, pp. 76–78, 89–90, 114, 116, 119, 120.

1909.332 The Feeding Habits of Mœritherium and Palæomastodon. Nature, LXXXI, No. 2074, July 29, pp. 139, 140, text figs. 1, 2.

1910.346 The Age of Mammals in Europe, Asia and North America. 8vo, The Macmillan Co., New York, pp. xvii+635, 220 text figs.

New subfamilies: Dinotheriinæ, Mastodontinæ, Elephantinæ.

1910.347 A Means of Estimating the Age of the Mastodon and Other Proboscidea. [Abstract.] Separates issued in 1910. Proc. Seventh Intern. Zool. Congress (Boston Meeting, Aug. 19–24, 1907), 1912, pp. 782–784, text figs. 1–3.

1914.409 Recent Results in the Phylogeny of the Titanotheres. Bull. Geol. Soc. Amer., XXV, Sept. 15, pp. 403–405, text fig. 1.

Abstract: Bull. Geol. Soc. Amer., XXV, No. 1, March, 1914, p. 139.
Principles of phylogeny.

1914.411 Restoration of the World Series of Elephants and Mastodons. Bull. Geol. Soc. Amer., XXV, Sept. 15, pp. 407–410, text figs. 1, 2.

Six models (one-eighth scale) by Charles R. Knight.

1915.418 Review of the Pleistocene of Europe, Asia and Northern Africa. Ann. New York Acad. Sci., XXVI, July 30, pp. 215–315, text figs. 1–20.

Osborn, Henry Fairfield—Continued

1918.468 A Long-Jawed Mastodon Skeleton from South Dakota and Phylogeny of the Proboscidea. [Abstract.] Bull. Geol. Soc. Amer., XXIX, March, pp. 133–137, 1 chart.

New families: Dinotheriidæ, Mastodontidæ.
New subfamilies: Bunomastodontinæ, Stegodontinæ, Loxodontinæ, Longirostrinæ, Rhynchorostrinæ, Brevirostrinæ.
New species: *Rhynchotherium tlaxcalæ* [=*tlascalæ*].

1918.473 Equidæ of the Oligocene, Miocene, and Pliocene of North America, Iconographic Type Revision. Mem. Amer. Mus. Nat. Hist., N.S., II, Pt. I, June 10, 330 pp., 54 pls., 173 text figs.

Correlation of Tertiary horizons.

1919.492 Palæomastodon, the Ancestor of the Long-Jawed Mastodons Only. Proc. Nat. Acad. Sci., V, Aug. 26, pp. 265, 266, text fig. 1.

1921.515 The Evolution, Phylogeny, and Classification of the Proboscidea. Amer. Mus. Novitates, No. 1 [Dated Jan. 31, 1921—Issued Feb. 3, 1921], 15 pp., 4 text figs.

New superfamilies: Mœritherioidea, Dinotherioidea, Mastodontoidea, Elephantoidea. New family: Bunomastodontidæ. New subfamily: Mammontinæ. New species: *Trilophodon giganteus, Tetralophodon barbouri.* Neotype of *Rhynchotherium tlaxcalæ* [made by Osborn in the present Memoir the type of *R. browni*].

1921.522 First Appearance of the True Mastodon in America. Amer. Mus. Novitates, No. 10, June 15, pp. 1–6, text figs. 1, 2.

New species: *Mastodon tapiroides americanus* (Schlesinger in Osborn), *Mastodon matthewi, Mastodon merriami.*

1921.523 The First Appearance of the True Mastodon in America. Science, N.S., LIV, No. 1388, Aug. 5, p. 108.

Correction of statement made in 1921.522: *Mastodon merriami* of Middle Miocene rather than of Middle Pliocene age.

1921.524 Heads of African Elephants—Disparity in Size between that of the Male and that of the Female. Nat. Hist., XXI, No. 3, May–June, pp. 244, 245, 1 text fig.

Loxodonta africana.

1921.526 Evolution, Phylogeny, and Classification of the Mastodontoidea. Bull. Geol. Soc. Amer., XXXII, pp. 327–332 [Dated Sept. 1, 1921—Issued Oct. 5, 1921].

New subfamilies: Serridentinæ, Notorostrinæ.

1921.532 Adaptive Radiation and Classification of the Proboscidea. Proc. Nat. Acad. Sci., VII, No. 8, pp. 231–234, text fig. 1. [Dated Aug. 1921—Issued Dec. 19, 1921].

Diagram showing principle of adaptive radiation of the Proboscidea, June, 1921.

1922.553 Close of the Age of Mammals. [Abstract only.] Science, N.S., LV, No. 1432, June 9, p. 627. (With H. E. Anthony.)

1922.555 Species of American Pleistocene Mammoths, Elephas jeffersonii, New Species. Amer. Mus. Novitates, No. 41, July 8, 16 pp., 12 text figs.

New species: *Elephas jeffersonii.*

1922.563 Pliocene (Tertiary) and Early Pleistocene (Quaternary) Mammalia of East Anglia, Great Britain, in Relation to the Appearance of Man. Geol. Mag., LIX, No. 700, October, pp. 433–441, folding table.

List of Vertebrata found in the "Forest Bed" Series of Norfolk and Suffolk.

1922.564 Dibelodon edensis (Frick) of Southern California, Miomastodon of the Middle Miocene, New Genus. Amer. Mus. Novitates, No. 49, Oct. 23, 4 pp., 1 text fig.

New genus: *Miomastodon.*
Reference of *Trilophodon (Tetrabelodon) shepardi edensis* Frick to *Dibelodon.*

1922.566 Migrations and Affinities of the Fossil Proboscideans of Eurasia, North and South America, and Africa. Amer. Naturalist, LVI, No. 646, pp. 448–455, text fig. 1. [Issued Oct. 24.]

Eocene adaptive radiation into four great primary stocks.

1922.568 Close of the Age of Mammals. Journ. Mamm., III, No. 4, pp. 219–237. (With H. E. Anthony.) [Issued Nov. 4.]

1922.569 Note . . . (to) Revision of Palæomastodon and Mœritherium . . . by H. Matsumoto. Amer. Mus. Novitates, No. 51, Nov. 21, p. 6.

1922.570 Old and New Standards of Pleistocene Division in Relation to the Prehistory of Man in Europe. Bull. Geol. Soc. Amer., XXXIII, pp. 411–490, text figs. 1–14. (With Chester Albert Reeds.)

Correlation table (cf. Osborn, 1930.820, fig. 3, for revised table).

1923.574 Mastodons of the Hudson Highlands. Nat. Hist., XXIII, No. 1, January–February, pp. 3–24, frontispiece and 14 text figs. [Issued Feb. 5.] Abstract, Illus. London News, CLXII, No. 4390, June 9, 1923, pp. 992, 993.

Early history of the Hudson River mastodonts.

1923.601 New Subfamily, Generic, and Specific Stages in the Evolution of the Proboscidea. Amer. Mus. Novitates, No. 99, Dec. 27, 4 pp.

New subfamilies: Mœritheriinæ, Zygolophodontinæ.
New genera: *Cuvieronius, Serridentinus, Prostegodon* Matsumoto (in Osborn).
New species: *Serridentinus simplicidens, Trilophodon progressus, Tetralophodon precampester, Rhynchotherium rectidens, Rhynchotherium falconeri, Elephas washingtonii.* Correction as to paratype of *Elephas jeffersonii.*

1923.603 Linnaean Classification and Phylogenetic Classification of the Proboscidea. Palaeontologia Hungarica, I (1921–1923), pp. 35–54, text figs. 1–5. Budapest.

Principles of phylogenetic classification.

1924.630 Serridentinus and Baluchitherium, Loh Formation, Mongolia. Amer. Mus. Novitates, No. 148, Nov. 11, 5 pp., 2 text figs.

New species: *Serridentinus mongoliensis.*

1924.632 Factors in the Evolution and Phylogeny of the Proboscidea. [Abstract.] Anat. Record, XXIX, No. 2, pp. 114, 115.

1924.633 Parelephas in Relation to Phyla and Genera of the Family Elephantidæ. Amer. Mus. Novitates, No. 152, Dec. 20, 7 pp., 2 text figs.

New genera. *Sivalikia, Pilgrimia, Parelephas.*
New subspecies: *Mammonteus primigenius compressus, Parelephas jeffersonii progressus.*

1924.634 Additional Generic and Specific Stages in the Evolution of the Proboscidea. Amer. Mus. Novitates, No. 154, Dec. 24, 5 pp., 2 text figs.

New subgenera: *Morrillia, Lydekkeria.* New species: *Stegomastodon texanus, Stegomastodon aftoniæ, Stegomastodon nebrascensis* [=*Serridentinus nebrascensis*].

1925.637 The Elephants and Mastodonts Arrive in America. Nat. Hist., XXV, No. 1, January–February, pp. 3–23, frontispiece and 17 text figs. [Feb. 27, 1925.] Reprinted as Guide Leaflet No. 62, Amer. Mus. Nat. Hist., 1926.

1925.662 Final Conclusions on the Evolution, Phylogeny, and Classification of the Proboscidea. Proc. Amer. Phil. Soc., LXIV, No. 1, Aug. 7, pp. 17–35, text figs. 1–3.

1925.670 Mammals and Birds of the California Tar Pools. Nat. Hist., XXV, No. 6, November–December, pp. 527–543, text figs. 1–13. [Issued Dec. 23.]

Includes remains of *Mastodon americanus* and *Archidiskodon imperator.*

1926.706 Additional New Genera and Species of the Mastodontoid Proboscidea. Amer. Mus. Novitates, No. 238, Nov. 30, 16 pp., 12 text figs.

New genera: *Pliomastodon, Turicius, Cordillerion.* New species and subspecies: *Mastodon americanus plicatus, Zygolophodon pyrenaicus aureliaensis, Turicius turicensis simorrensis, Serridentinus browni, S. republicanus, S. obliquidens, S. anguirvalis, S. brewsterensis, S. guatemalensis, Rhynchotherium anguirvalis, Anancus falconeri.*

1928.749 Mammoths and Man in the Transvaal. Nature, CXXI, No. 3052, Apr. 28, pp. 672, 673, text figs. 1, 2.

New species: *Archidiskodon subplanifrons, A. broomi.*

1929.769 The Revival of Central Asiatic Life. Nat. Hist., XXIX, No. 1, [Jan. 29], pp. 3–16, frontispiece and 16 text figs.

New species: *Amebelodon grangeri* [subsequently referred to *Platybelodon grangeri*].
Translation (by Dr. Ahrens), "Die Wiederweckung ausgestorbener Tiergeschlechter Zentralasiens." Der Naturforscher, 6 Jahrgang, 1929, pp. 6–16.

1929.795 Ancient Migration Routes of Central Asia. Science, N. S., LXX, No. 1826, pp. 638, 639, Charts I, II.

Chart I—Migration lines of Sauropoda (Mesozoic), of Proboscidea (Cenozoic). Chart II—World centers of mammalian origin in order of discovery.

1929.797 New Eurasiatic and American Proboscideans. Amer. Mus. Novitates, No. 393, Dec. 24, 23 pp., 22 text figs.

New genus: *Synconolophus.*
New species and subspecies: *Trilophodon angustidens gaillardi, Serridentinus bifoliatus, S. hasnotensis, S. metachinjiensis, S. chinjiensis, S. prochinjiensis, S. florescens, Rhynchotherium paredensis, R. chinjiensis, Synconolophus dhokpathanensis, S. ptychodus, S. propathanensis, Stegolophodon nathotensis, S. cautleyi progressus, Stegodon insignis birmanicus, S. orientalis grangeri, S. pinjorensis, Archidiskodon sonoriensis, Parelephas floridanus, P. columbi cayennensis, Elephas platycephalus,* and *Elephas platycephalus angustidens.*

Osborn, Henry Fairfield—Continued

1929.800 The Titanotheres of Ancient Wyoming, Dakota, and Nebraska. Monograph 55, U. S. Geological Survey, I, II. 4to, Government Printing Office, Washington.

1930.813 Biographical Memoir of Edward Drinker Cope, 1840-1897. Biogr. Memoirs, Nat. Acad. Sci., XIII, Third Mem., pp. 125-317.

Compare "Cope: Master Naturalist," Osborn, 1931.849.

1930.820 Influence of the Glacial Age on the Evolution of Man. Bull. Geol. Soc. Amer., XL, May, pp. 589-595, text figs. 1-3. [Dated Dec. 31, 1929; not issued until May, 1930.]

Modified Osborn-Reeds Correlation Table of 1922 (see fig. 3).

1930.824 The Romance of the Woolly Mammoth. Nat. Hist., XXX, No. 3, May–June, pp. 227–241, frontispiece, 17 text figs., and tailpiece.

1930.828 On the Extinction of Mammals in the Lorian Swamp During the Drought of 1928. (Note.) Nat. Hist., XXX, No. 4, July–August, pp. 442, 443.

1930.829 Mediterranean Land Bridges. (Note.) Nat. Hist., XXX, No. 4, July–August, pp. 444, 445.

1930.832 Ancient Vertebrate Life of Central Asia. Discoveries of the Central Asiatic Expeditions of the Museum of Natural History in the Years 1921–1929. In "Livre Jubilaire publié à l'occasion du Centenaire de la Société Géologique de France, 1830-1930," pp. 519–543, text figs. 1–8.

Serridentinus, *Platybelodon*, p. 520, *Amebelodon*, p. 541.

1930.837 Parelephas floridanus from the Upper Pleistocene of Florida compared with P. jeffersonii. Amer. Mus. Novitates, No. 443, Dec. 18, 17 pp., 9 text figs.

1931.846 Palæoloxodon antiquus italicus sp. nov., Final Stage in the 'Elephas antiquus' Phylum. Amer. Mus. Novitates, No. 460, Mar. 10, 24 pp., 17 text figs.

Provisional reference of *Palæoloxodon antiquus italicus* to a new genus, *Hesperoloxodon* Osborn, p. 21.

1931.847 The Shovel-Tuskers, Amebelodontinæ, of Central Asia. Amer. Mus. Novitates, No. 470, April 10, 12 pp., 3 text figs. (With Walter Granger.)

Platybelodon danovi Borissiak. Reference of *Amebelodon grangeri* Osborn, 1929, to the genus *Platybelodon* Borissiak.

1931.849 Cope: Master Naturalist. 8vo, Princeton University Press, Princeton, N. J., pp. xvi+740, 30 text figs. (With the cooperation of Helen Ann Warren.)

1931.858 The Elephant Enamel Method of Measuring Pleistocene Time. Also Stages in the Succession of Fossil Man and Stone Age Industries. Proc. Amer. Phil. Soc., LXX, pp. 187-191. (With Edwin Harris Colbert.)

Evolution of the length and thickness of the enamel foldings of the third superior and inferior grinders in the *Archidiskodon*, *Parelephas*, *Mammonteus*, *Hesperoloxodon*, *Loxodonta*, and true *Elephas* phyla. Compare Sandford, 1925.1, on molar measurement and lamellar frequency.

1931.870 New Concept of Evolution Based Upon Researches on the Titanotheres and the Proboscideans. Science, N.S., LXXIV No. 1927, Dec. 4, pp. 557–559.

Six principles of the new evolutionary concept.

1932.874 The Nine Principles of Evolution Revealed by Palaeontology. Amer. Naturalist, LXVI, January–February, pp. 52–60.

First use of the word "aristogenesis."

1932.877 New Estimates of the Length of Pleistocene Time and Means of dating the Stone Age Man by the Elephant-Enamel Method. Rept. Centenary Meeting, Brit. Assn. Adv. Sci., London, 1931, pp. 372, 373.

1932.880 The Geologic Age of Pithecanthropus, Eoanthropus, and other Fossil Men determined by the Enamel-Ridge-Plate-Grinding-Tooth-Measurement of the Proboscidea with which they were geologically contemporaneous. Rept. Meeting, Brit. Assn. Adv. Sci., London, 1931, pp. 451–453.

1932.886 Platybelodon grangeri, Three Growth Stages, and a New Serridentine from Mongolia. Amer. Mus. Novitates, No. 537, June 9, 13 pp., 8 text figs. (With Walter Granger.)

New species: *Serridentinus gobiensis*.

1932.893 The "Elephas meridionalis" Stage Arrives in America. Proc. Colo. Mus. Nat. Hist., XI, No. 1, Sept. 7, pp. 1–3, text figs. 1, 2.

New subspecies: *Archidiskodon meridionalis nebrascensis*.

1932.896 Trilophodon cooperi, Sp. Nov., of Dera Bugti, Baluchistan. Amer. Mus. Novitates, No. 585, Nov. 15, 6 pp., 2 text figs.

1932.897 Biological Inductions from the Evolution of the Proboscidea. Science, LXXVI, No. 1979, pp. 501–504, Dec. 2, 1932; Proc. Nat. Acad. Sci., XIX, No. 1, pp. 159–163, January, 1933.

1933.908 Des principes qui ont présidé à l'évolution biomécanique des Mammifères. Compt. Rend. Acad. Sci., CXCVI, No. 24, pp. 1760–1763. Paris.

1933.909 Serbelodon burnhami, a New Shovel-tusker from California. Amer. Mus. Novitates, No. 639, June 29, 5 pp., 2 text figs.

A giant species compared with the smaller *Serbelodon barbourensis*.

1933.911 Aristogenesis, the Observed Order of Biomechanical Evolution. Proc. Nat. Acad. Sci., XIX, No. 7, July, pp. 699–703.

Aristogenesis defined. Aristogenes of the *Trilophodon* phylum.

1933.915 Aristogénèse, le nouveau principe inductif d'évolution biomécanique. Revue Générale des Sciences, XLIV, Nos. 17, 18, 15–30 Septembre, pp. 495–505, text figs. 1–8. Paris.

1934.919 Aristogenesis, the Creative Principle in the Origin of Species. Science, LXXIX, No. 2038, Jan. 19, pp. 41–45.

Aristogenes and alloiometrons in the biomechanical evolution of the grinding teeth and tusks of the Proboscidea.

1934.922 Aristogenesis, the Creative Principle in the Origin of Species. Amer. Naturalist, LXVIII, No. 716, pp. 193–235.

First use of the name Humboldtinæ.

1934.924 Evolution and Geographic Distribution of the Proboscidea: Moeritheres, Deinotheres and Mastodonts. Journ. Mamm., XV, No. 3, August, pp. 177–184.

Humboldtinæ (name only, fig. 2). *Eubelodon* ancestral form of *Cuvieronius guatemala* and *C. superbus*. *C. poltermus* and *C. ayerx* related mountain-loving forms; said to be associated with human remains, p. 183.

1934.925 Primitive Archidiskodon and Palæoloxodon of South Africa. Amer. Mus. Novitates, No. 741, Aug. 24, 15 pp., 5 text figs.

New genus: *Metarchidiskodon*, genotype *Loxodonta grajus* Haughton.
New species: *Archidiskodon proplanifrons*.

1934.926 The Thirty-nine Distinct Lines of Proboscidean Descent, and their Migration into all Parts of the World except Australia. Proc. Amer. Phil. Soc., LXXIV, No. 4, August, pp. 273–285, text figs. 1–4.

New subfamily: Humboldtinæ, fig. 3; see also p. 283 for included species.
New genera: *Hypselephas* and *Platelephas*, p. 283.
New species (without description): *Rhynchotherium brevesi*, *Tetralophodon fricki*, *Pentalophodon falconeri*, and *Anancus progressus*.

1935.937 The Ancestral Tree of the Proboscidea. Discovery, Evolution, Migration and Extinction over a 50,000,000 Year Period. Proc. Nat. Acad. Sci., XXI, No. 6, June, pp. 404–412, text figs. 1–5.

First use of the superfamily name Stegodontoidea.
New families: Serridentidæ and Humboldtidæ (names only), see fig. 2. Transfer of *Notiomastodon* to the Serridentidæ, fig. 2.

1935.942 Thomas Jefferson as a Paleontologist. Science, N. S., LXXXII, No. 2136, Dec. 6, pp. 533–538.

Jefferson's views regarding the Mastodon and the Mammoth.

Osborn, Henry Fairfield, and Harold Elmer Anthony
See Osborn, Henry Fairfield, 1922.553, 1922.568.

Osborn, Henry Fairfield, and Edwin Harris Colbert
See Osborn, Henry Fairfield, 1931.858.

Osborn, Henry Fairfield, and Walter Granger
See Osborn, Henry Fairfield, 1931.847 and 1932.886.

Osborn, Henry Fairfield, and William Diller Matthew
See Osborn, Henry Fairfield, 1909.321.

Osborn, Henry Fairfield, and Chester Albert Reeds
See Osborn, Henry Fairfield, 1922.570.

Osborn, Henry Fairfield, and Jacob L. Wortman
See Osborn, Henry Fairfield, 1892.67.

Oswald, Felix, Charles William Andrews, and Richard Bullen Newton

1914.1 The Miocene Beds of the Victoria Nyanza and the Geology of the Country between the Lake and the Kisii Highlands. With an Appendix on the Vertebrate Remains, by Charles William Andrews, D.Sc., F.R.S., F.G.S.; and an Appendix on the Non-Marine Mollusca, by Richard Bullen Newton, F. G. S. Quart Journ. Geol. Soc. London, LXX, June, pp. 128–198, Pls. xx–xxx.

The Appendix by Charles W. Andrews is entitled "Lower Miocene Vertebrates from British East Africa, Collected by Dr. Felix Oswald," pp. 163–186, Pls. xxvii–xxix, in which he refers a ramus from near Karungu to *Dinotherium hobleyi*.

Owen, Richard

1840-1845 Odontography; or, a Treatise on the Comparative Anatomy of the Teeth; their Physiological Relations, Mode of Development, and Microscopic Structure, in the Vertebrate Animals. I (Text), pp. xix+lxxiv+655; II (Atlas), 19 pp., 149 pls. 8vo, London.

Dinotherium, pp. 609–612; *Mastodon*, pp. 613–625; *Elephas*, pp. 625–655.

1843.1 On the Discovery of the Remains of a Mastodontoid Pachyderm in Australia. Ann. Mag. Nat. Hist., XI, No. 67, January, pp. 7–12, text figs. 1–3.

Mastodon or *Dinotherium*.

1843.2 Additional Evidence proving the Australian Pachyderm described in a former Number of the 'Annals' to be a Dinotherium, with remarks on the Nature and Affinities of that genus. Ann. Mag. Nat. Hist., XI, No. 71, May, pp. 329–332, text figs. 1, 2.

New species: *Dinotherium Australe* [subsequently determined as *Diprotodon australis*].

1844.1 Description of a Fossil Molar Tooth of a Mastodon Discovered by Count Strzlecki in Australia. Ann. Mag. Nat. Hist., XIV, No. 91, October, pp. 268–271, text figs. 1, 2.

Mastodon australis [=*Diprotodon australis*].

1846.1 A History of British Fossil Mammals, and Birds. 8vo, London, pp. xlvi+560, 237 text figs.

Elephas primigenius, pp. 217, 218, 270; *Mastodon angustidens*, pp. 271–298. Figure of the Mammoth of Siberia, p. 217.

1859.1 Address of the President. Rept. Brit. Assoc. Adv. Sci., 28th Meeting, Leeds, pp. xlix-cx.

[*Elephas texianus* (name only); see Charles Carter Blake (1862.1, p. 58) for description.]

1866-1868 On the Anatomy of Vertebrates, I–III. 8vo, London.

Proboscidea, Vol. II (skeletal description), pp. 437–444; Vol. III, Proboscidea (dental formulæ, also *Dinotherium*), pp. 358–366.

1870.1 On Fossil Remains of Mammals found in China. Quart. Journ. Geol. Soc. London, XXVI, Pt. I, pp. 417–434, Pls. xxvii–xxix.

New species: *Stegodon sinensis*, *S. orientalis*.

1882.1 Description of the Fossil Tusk of an extinct Proboscidian Mammal (Notelephas australis, Ow.), from Queensland, Australia. Proc. Roy. Soc. London, XXXIII, p. 448 (abstract).

New genus: *Notelephas* [=*Diprotodon australis*].

1883.1 Description of portions of a Tusk of a Proboscidian Mammal. (Notelephas australis, Owen.) Phil. Trans. Roy. Soc. London, CLXXIII, Pt. III, pp. 777–781, Pl. li.

Pallas, Peter Simon

1777 (1780) Observatio de Dentibus Molaribus Fossilibus Ignoti Animalis, Canadensibus Analogis, Etiam ad Uralense Iugum Repertis. Acta Acad. Sci. Imp. Petropol., pp. 213–222, Tab. i–xiv. [Commonly dated 1777, although title-page gives for the year 1777, date 1780.]

Molar regarded by Pallas as related to the "Mastodonte de l'Ohio," but later referred by Eichwald and De Blainville to *Mastodon tapiroides* [probably *Zygolophodon*].

Palmer, Rupert William

1924.1 An Incomplete Skull of Dinotherium, with Notes on the Indian Forms. Mem. Geol. Surv. India, Palaeont. Indica, N.S., VII, Mem. No. 4, pp. 1–13, Pls. i–iii.

Agrees with Weinsheimer (1883) that *D. indicum* and *D. pentapotamiæ* are not true species but are based on the remains of casual variations of the European form [*D. giganteum*].

Palmer, Theodore Sherman

1904.1 Index Generum Mammalium. North American Fauna, No. 23, Jan. 23, 984 pp. 8vo, Washington, D. C.

Patte, Étienne

1931.1 A propos d'un Elephas namadicus signale en Annam. Quelques mots sur la frequence laminaire. Bull Soc. géol. France, (5), I, pp. 743–750, Pl. xliii.

Paulli, Simon, and Johan Erik Vesti Boas

1908–1925 See Boas, Johan Erik Vesti, and Simon Paulli.

Pavlow, Marie (Pavlova, Marija Vasil'evna)

1894.1 Les Mastodontes de la Russie et Leurs Rapports avec Les Mastodontes des Autres Pays. Mém. Acad. Imp. Sci. St. Pétersb., (8), I, No. 3, pp. 1–43, Pl. i–iii.

Mastodon ohioticus, *M. borsoni* treated at length; remarks on the geologic age and geographic distribution of the Zygolophodonts.

1901.1 Nouvelles trouvailles de Mastodon Borsoni Lart. au sud de la Russie. Annuaire Géol. Min. Russie, V, Livr. 2–3, pp. 9–18, Pl. i.

Mastodon Borsoni, *M. ohioticus*, and *M. brevidens*.

1909.1 Les éléphants posttertiaires de diverses localités en Russie. Annuaire Géol. Min. Russie, XI, Livr. 6–7, pp. 171–174, Pl. v.

New species: *Elephas wüsti*, p. 172, Pl. v, figs. 1, 2.

1910.1 Les Éléphants Fossiles de la Russie. Nouv. Mém. Soc. Imp. Nat. Moscou, XVII (forming XXII of the collection), Livr. 2, pp. 1–60, Pls. i–iii.

Supplementary description in detail of *Elephas wüsti*.

1931.1 Les Elephants Fossiles du Sud de l'USSR. All Ukrainian Acad. Sci., II, pp. 67–85, Pls. i, ii, text figs. 1, 2.

Treats the species *Elephas planifrons*, *E. meridionalis*, *E. wüsti*.

1931.2 Les Restes des Ossements des Mastodontes Provenant de L'Ancien Gouvernement de Kherson. Inst. Paléozool. Acad. Sci. l'USSR, I, pp. 69–79, Pls. i, ii.

Pearson, Helga Sharpe

1928.1 Chinese Fossil Suidæ. Pal. Sinica, (C), V, Fasc. 5, September, 75 pp., 4 pls., 37 text figs. Peiping (Peking).

Pennant, Thomas

1771.1 Synopsis of Quadrupeds. 8vo, Chester, pp. xxv+382, 31 pls.

American Elephant.

1793.1 History of Quadrupeds. 3d edition. I, pp. xxx+306, Pls. i–lxx; II, pp. 324+Index, Pls. lxi–cix. R.8vo, London.

Elephant, Vol. I, pp. 165–176.

Perry, George

1811.1 Arcana: or the Museum of Natural History: containing the Most Recent Discovered Objects. Embellished with Coloured Plates, and Corresponding Descriptions; with Extracts relating to Animals, and Remarks of Celebrated Travellers, combining a General Survey of Nature. Vols. I and II, 8vo, London.

This work appeared in twenty-one monthly installments (1810–1811) and is without page or plate numbers. Mathews and Iredale give an excellent résumé of this work under the title "'Perry's Arcana'—an Overlooked Work," The Victoria Naturalist: The Journal & Magazine of the Field Naturalists' Club of Victoria, XXIX, 1912, May, pp. 7–16, in which they have assigned to the Plates, the numbers i–lxxxiv.

New species: *Elephas gigas* [=*Elephas indicus*], description of four pages, Pl. Ii (Pl. lxi of Mathews and Iredale). *Elephas socotrus* also mentioned (but without figure) as residing in Thibet, being much smaller than *E. gigas* and of "an opposite form."

Peters, Carl Ferdinand

1871.1 Ueber Reste von Dinotherium aus der obersten Miocänstufe der südlichen Steiermark. Mitt. naturw. Ver. Steiermark, II, Heft III, pp. 367–398, Taf. i–iii, 2 text figs.

Peterson, Olof August

1928.1 The Brown's Park Formation. Mem. Carnegie Mus., XI, No. 2, pp. 87–130, Pls. ix–xv, text figs. 1–24. (Issued Apr. 8.)

New species: *Serridentinus fricki* [=*Trilophodon fricki*]. Referred *Parelephas washingtonii* from Colorado.

Petronievics, Branislav

1923.1 Remarks upon the Skulls of Mœritherium and Palæomastodon. Ann. Mag. Nat. Hist., (9), XII, pp. 55–61, Pl. ii, text figs. 1, 2.

New species: *Mœritherium ancestrale*, p. 57.

Peyrony, D., Joseph-Louis Capitan, and Henri Breuil

1924.1 See Capitan, Joseph-Louis, Henri Breuil, and D. Peyrony.

Pfizenmayer, E. W.

1905.1 Beitrag zur Morphologie von Elephas primigenius, Blumenb. und Erklärung meines Reconstructionsversuches. Verh. russisch.-kaiserl. Min. Ges. St. Petersb., (2), XLIII, pp. 521–542, Taf. VII, text figs. 1–4.

1926.1 Mammutleichen und Urwaldmenschen in Nordost-Sibirien. 8vo, Leipzig, 341 pp., 95 text figs., 3 maps.

Philippi, Rudolph Amandus

1893.1 Vorläufige Nachricht über fossile Säugethierknochen von Ulloma, Bolivia. Zeitschr. deutsch. geol. Ges., XLV, pp. 87–96, text figs. 1–9a.

New species: *Mastodon chilensis*, *M. bolivianus*.

Phillips, Philip Lee

1901.1 A List of Maps of America in the Library of Congress.

See especially p. 838 for map of Big-Bone Lick, Ky.

Pictet, François Jules

1853–1857 Traité de Paléontologie. 2d edition. I (1853, pp. xiv+584), II (1854, pp. 1–727), III (1855, pp. 1–654), IV (1857, pp. xvi+768), 8vo; also Atlas, 110 pls. and 77 pp., 4to. Paris.

Proboscidea, Vol. I, pp. 279–291 (Pl. IX of Atlas); *Dinotherium*, pp. 369–372 (Pl. XVIII of Atlas).

Pilgrim, Guy Ellcock

1905.1 On the Occurrence of Elephas antiquus (namadicus) in the Godavari Alluvium, with Remarks on the Species, its distribution and the age of the associated Indian deposits. Rec. Geol. Surv. India, XXXII, Pt. III, pp. 199–218, Pls. IX–XIII, 1 text fig.

Elephas antiquus (namadicus) [=*Palæoloxodon namadicus*] of Paitán, Godávari Alluvium, Pls. X–XII.

1908.1 The Tertiary and Post-Tertiary Freshwater Deposits of Baluchistan and Sind with notices of new Vertebrates. Rec. Geol. Surv. India, XXXVII, Pt. II, pp. 139–166, Pls. II–IV.

New species: *Dinotherium náricum*, p. 156; *Tetrabelodon crepusculi*, p. 157.

1910.1 Notices of New Mammalian Genera and Species from the Tertiaries of India. Rec. Geol. Surv. India, XL, Pt. I, pp. 63–71.

Mæritherium (?) sp., p. 67.

1910.2 Preliminary Note on a Revised Classification of the Tertiary Freshwater Deposits of India. Rec. Geol. Surv. India, XL, Pt. III, pp. 185–205.

Important Correlation Table.

1912.1 The Vertebrate Fauna of the Gaj Series in the Bugti Hills and the Punjab. Mem. Geol. Surv. India, Palæont. Indica, N.S., IV, Mem. 2, pp. ii+83, 30 pls., geologic map.

New genus: *Hemimastodon* [=Suina]. Transference of *Tetrabelodon crepusculi* Pilgrim, 1908, to the genus *Hemimastodon* [=Suina]. New variety: *Dinotherium indicum* var. *gajense*, first named *Dinotherium náricum* by Pilgrim in 1908. *Mæritherium* (?) sp., from Khajuri, Bugti Hills (possibly referable to *Trilophodon pandionis*).

1913.1 The Correlation of the Siwaliks with Mammal Horizons of Europe. Rec. Geol. Surv. India, XLIII, Pt. IV, pp. 264–326, Pls. XXVI–XXVIII.

New species: *Tetrabelodon corrugatus*, *Mastodon hasnoti*, *M. stegodontoides*, *Tetrabelodon macrognathus*. Plate XXVI is an excellent table "Classification of the Tertiary River Deposits of India."

1915.1 New Siwalik Primates and their bearing on the question of the Evolution of Man and the Anthropoidea. Rec. Geol. Surv. India, XLV, Pt. I, pp. 1–74, Pls. I–IV.

1918.1 Preliminary Note on some recent Mammal Collections from the Basal Beds of the Siwaliks. Rec. Geol. Surv. India, XLVIII, Pt. II, pp. 98–101.

Fauna and geologic age of the Manchhar, Chinji, Kamlial, and Grive Saint-Alban.

1926.1 The Tertiary Formations of India, and the Interrelation of the Marine and Terrestrial Deposits. Proc. Pan-Pacific Sci. Cong. (Australia), 1923 (issued in May, 1926), pp. 896–933, text figs. 1–4.

1926.2 The Fossil Suidæ of India. Mem. Geol. Surv. India, Palæont Indica, N.S., VIII, Mem. 4, 65 pp., 20 pls.

Pilgrim, Guy Ellcock, and G. de P. Cotter

1916.1 Some Newly Discovered Eocene Mammals from Burma Rec. Geol. Surv. India, XLVII, Pt. I, pp. 42–79, Pls. I–VI.

Plate, Ludwig

1925.1 Die Abstammungslehre, Tatsachen, Theorien, Einwände und Folgerungen in kurzer Darstellung. Zweite Auflage des "Leitfadens der Deszendenztheorie." 8vo, Jena, pp. vii+72, 94 text figs.

Proboscidea, pp. 56–58, Pls. 35–37.

Pohle, Hermann

1926.1 Notizen über afrikanische Elephanten. Zeits. Säugetierkunde, I, Heft I, pp. 58–64, Taf. II, text fig. 1.

Loxodonta africana pumilio of Noack.

Pohlig, Hans

1884.1 Vorläufige Mittheilungen über das Pliocaen, insbesondere Thüringens. Sitz.-Ber. niederrhein. Ges. Bonn, pp. 47–61.

1885.1 Ueber eine Hipparionen-Fauna von Maragha in Nordpersien, über fossile Elephantenreste Kaukasiens und Persiens und über die Resultate einer Monographie der fossilen Elephanten Deutschlands und Italiens. Zeitschr. deutsch. geol. Ges., XXXVII, Heft IV, pp. 1022–1027.

Archibiskodonten, Loxodonten, Polydiskodonten, Stegodonten. New species: *Elephas trogontherii*.

1886.1 On the Pliocene of Maragha, Persia, and its Resemblance to that of Pikermi in Greece; on Fossil Elephant Remains of Caucasia and Persia; and on the Results of a Monograph of the Fossil Elephants of Germany and Italy. Quart. Journ. Geol. Soc. London, XLII, pp. 177–182. Discussion by W. Boyd Dawkins and Richard Lydekker, pp. 181, 182.

Elephas trogontherii Pohl. holds a middle place, both zoologically and geologically, between those of *E. primigenius* and *E. meridionalis*.

1887.1 Ueber Elephas trogontherii und Rhinoceros Merckii von Rixdorf bei Berlin. Zeitschr. deutsch. geol. Ges., XXXIX, Heft IV, pp. 798–807, text fig.

First use of the form *Elephas (primigenius) trogontherii*, originally described by Pohlig (1885.1, p. 1027) as *Elephas trogontherii*.

1887.2 Molaren von Elephas und Rhinoceros von Rixdorf bei Berlin. Sitz.-Ber. niederrhein. Ges. Bonn, December, pp. 274–279.

First use of the form *Elephas (primigenius* bezw. *meridionalis) trogontherii*.

1888, 1891 Dentition und Kranologie des Elephas antiquus Falc. mit Beiträgen über Elephas primigenius Blum. und Elephas meridionalis Nesti. Nova Acta Leop. Carol., LIII, LVII. Halle.

1888, Band LIII, No. 1, Erster Abschnitt, pp. 1–279, 10 Taf., 110 text figs.
1891, Band LVII, No. 5, Zweiter Abschnitt, pp. 267–466, 7 Taf., 159 text figs.
New genera: *Loxo(disko)don*; *Polydiskodon*; *Stego(lopho)don*.
New species: *Elephas Nestii*, pp. 303, 304; *Elephas antiquus Nestii*, p. 465.

1892.1 Weiterer Nachtrag zu der Dentition von Elephas antiquus. Anhang in "Cerviden des thüringischen Diluvial-Travertines." Palæontogr., XXXIX, pp. 259–261.

Elephas Leith-Adamsi, *Elephas trogontherii*.

1893.1 Eine Elephantenhöhle Siciliens und der erste Nachweis des Cranialdomes von Elephas antiquus. Abh. bayer. Akad., II Cl., XVIII, Abth. I, pp. 73–108, Taf. I–V, text figs. 1–4. München.

Elephas antiquus Melitæ of Grotte di Pontale.

1909.1 Über Elephas trogontherii in England. Monatsber. deutsch. geol. Ges., LXI, No. 5, pp. 242–249, 1 pl., 1 text fig.

Elephas trogontherii, *E. (antiquus) Nestii*, and associated fauna.

1911.1 Zur Osteologie von Stegodon. In "Die Pithecanthropus-Schichten auf Java," Selenka and Blanckenhorn, pp. 196–213, Taf. XXVI, XXVII, text figs. 1–6.

1912.1 Sur une vieille mandibule de "Tetracaulodon ohioticum" Blum., avec défense in situ. Bull. Soc. belge Géol., XXVI, Procès-verbaux, October, pp. 187–193, text figs. 1, 2.

New genera: *Promastodon*, *Stegomastodon*.

Pomel, August

1848.1 Sur la classification des mammifères onguléS. Bull. Soc. géol. France, (2), V, pp. 256, 257.

Dinotherium classed as one of the Proboscidea, p. 257.

1848.2 Les Mastodontes de l'Europe occidentale. Bull. Soc. géol. France, (2), V, pp. 257–259.

New species: *Mastodon Buffonis*, frequently accompanying *M. angustidens*, p. 258.
Discussion (pp. 258, 259) regarding the European and American horizons in which the mastodonts and elephants are found, especially *M. angustidens*, *M. cuvieri*, *M. tapiroides*, and *Elephas primigenius*.

Pomel, August—Continued

1853.1 Catalogue Méthodique et descriptif des Vertébrés Fossiles. . . 12mo, Paris, 193 pp.
Classes *Dinotherium* with *Elephas* and *Mastodon* among the Proboscidea, pp. 74–76.

1879.1 Ossements d'Éléphants et d'Hippopotames découverts dans une station préhistorique de la plaine d'Eghis (province d'Oran). Bull. Soc. géol. France, (3), VII, pp. 44–51.
New species: *Elephas atlanticus*.

1895.1 Paléontologie Monographies, No. 6. Les Éléphants Quaternaires. Carte Géol. L'Algérie, 67 pp., 15 pls.
Supplementary description of *Elephas atlanticus*. New species: *Elephas jolensis*.

Pompeckj, Joseph Felix

1905.1 Mastodon-Reste aus dem interandinen Hochland von Bolivia. Palaeontogr., LII, pp. 17–56, Taf. III, IV.
Mastodon bolivianus Philippi emend. Pompeckj.

Pontier, G.

1907.1 Sur une espèce nouvelle de Paleomastodon (Paleomastodon Barroisi). Ann. Soc. géol. du Nord, XXXVI, pp. 150–154, text figs. 1, 2.
New species: *Paleomastodon Barroisi*.

1911.1 Remarques sur les variations dentaires chez les Éléphants quaternaires européens. Bull. Soc. géol. France, (4), XI, pp. 463–471, Pl. X.
Comparison of *Elephas meridionalis, E. antiquus, E. intermedius, E. primigenius*.

1926.1 Contribution à l'étude du Mastodon Turicensis-Schintz. Ann. Soc. géol. du Nord, LI, pp. 149–165, Pl. VIII.

Pontier, G., and Raoul Louis Ferdinand Anthony

1929.1 See Anthony, Raoul Louis Ferdinand, and G. Pontier.

Poppelack, F.

1858 [1848] Verzeichnisse tertiärer Petrefakten von vier und zwanzig Fundorten des Wienerbeckens. Haidinger's Ber. Mitt. Freunden Naturw. Wien, III, No. 1, pp. 13–19.
Dinotherium remains.

Portis, Alessandro

1893-1896 Contribuzioni alla Storia fisica del Bacino di Roma e studii sopra l'estensione da darsi al Pliocene superiore. 4to, Torino-Roma, I (1893); Torino, II (1896).
New subspecies: *Elephas meridionalis antiquitatis*, II, p. 272.

1896.1 Anomalie riscontrate sull'atlante di un elefante fossile dei dintorni di Roma. Riv. ital. Pal., II, pp. 326-331, 2 text figs.
E. (merid.) antiquitatis, p. 331.

Prime, A. J., and Ebenezer Emmons

1845.1 Great American Mastodon. Amer. Quart. Journ. Agric. and Sci., II, No. 2, October, pp. 203–212, Pl. IV.

Prouteaux, M., and Raoul Louis Ferdinand Anthony

1929.1 See Anthony, Raoul Louis Ferdinand, and M. Prouteaux.

Quackenbush, Lee Schuyler

1909.1 Notes on Alaskan Mammoth Expeditions of 1907 and 1908. Bull. Amer. Mus. Nat. Hist., XXVI, Art. IX, pp. 87–130, Pls. XVII–XXV.

Quenstedt, Friedrich August von

1850.1 Ueber Hippotherium der Bohnenerze. Jahresh. Ver. vaterl. naturk. Württemb., VI, pp. 165–185, Taf. I. Stuttgart.
Mastodon and *Dinotherium*, p. 180.

1853.1 Ueber die Fronstetter Fossilien, über Menschenzähne und über Stylolithen. Jahresh. Ver. vaterl. naturk. Württemb., IX, pp. 64–67, Taf. VII. Stuttgart.
Dinotherium, p. 66.

1867.1 Handbuch der Petrefaktenkunde. Zweite Auflage. (*Fide* Weinsheimer, 1883, p. 12; original not available).
Doubts whether *Dinotherium* should be classed with the pachyderms or the cetaceans, p. 63 (*fide* Weinsheimer).

Rachoy, Joseph

1863.1 Tertiäres Kohlenbecken von Leoben. Jahrb. geol. Reichsanst., XIII, Heft IV, [Verh.], December, pp. 136, 137. Wien.
Dinotherium bavaricum.

Rafinesque-Schmaltz, Constantine Samuel

1814.1 Compendio della ricerche del Sig. Cuvier sopra i Quadrupedi pachidermi fossili. Specchio Sci., II, No. 12, December, pp. 182, 183. Palermo.
New species: *Mastodon Macrodon, M. rhomboides, M. humboldianus, M. Senodon*, and *M. microdon*.

Ray, John

1693.1 Synopsis Methodica Animalium Quadrupedum et Serpentini Generis. 12mo, Londini: Impensis S. Smith & B. Walford Societatis Regiæ Typographorum ad Insignia Principis in Cœmeterio D. Pauli. Imprimatur, Robert Southwell, R.S.P., June 15, 1693, 358 pp.
Elephas, p. 131 [p. 123 of authors].

Réaumur, René Antoine Ferchault de

1715.1 Observations sur les Mines de Turquoises du Royaume; sur la nature de la Matiere qu'on y trouve, & sur la maniere dont on lui donne la couleur. Mem. Acad. Roy. Sci., Mat.-Phys., November, pp. 174–202, Pls. VII–IX. 4to, Paris.
Tooth of *Dinotherium* found near Lyons in early part of the 17th century and figured by Antoine de Jussieu; described by Réaumur, without a name, pp. 182, 183, Pl. VIII, figs. 17, 18.

Reck, Hans

1914.1 Zweite vorläufige Mitteilung über fossile Tier- und Menschenfunde aus Oldoway in Zentralafrika. Sitz.-Ber. Ges. naturf. Freunde Berlin, No. 7, pp. 305–318, text fig.
Elephas primigenius Fraasi Dietrich, *Elephas zulu* Scott.

1921.1 Letzte naturhistorische Funde aus Deutsch-Ostafrika. Der Kolonial-Deutsche, Jahrg. 1, No. 6, June, pp. 82–84, 1 text fig. Berlin.
Elephas antiquus recki Dietrich in the Museum für Naturkunde, Berlin.

1932.1 Der Mensch und die Kultur von Oldoway. Die Umschau Wiss. u. Technik, Jahrg. XXXVI, Heft XXXVI, Sept. 3, pp. 707–711, text figs. 1–12.
See especially p. 710, fig. 7, for molar fragment of *Dinotherium* from Oldoway.

Reeds, Chester Albert, and Henry Fairfield Osborn

1922.1 See Osborn, Henry Fairfield, 1922.570.

Reiss, Wilhelm, and Branco [Branca], Carl Wilhelm Franz

1883.1 Über Eine Fossile Säugethier-Fauna von Punin bei Riobamba in Ecuador. Geol. u. Pal. Abh., I, Heft II. I, Die geologischen Verhältnisse der Fundstellen fossiler Saugethier-Knochen in Ecuador (Reiss), pp. 41–56; II, Beschreibung der Fauna (Branco), pp. 57–204, Taf. VI–XXIV, Tab. I–XII. Jena.
Branco: Proboscidea, pp. 134–137 (*M. andium*). [Compare Spillmann (1928–1931) for *Cuvieronius postremus* and *C. ayoræ*.] Reiss: Stratigraphy of *M. andium*.

Reuss, August Emanuel

1852.1 Die geognostischen Verhältnisse des Egerer Bezirkes und des Ascher Gebietes in Böhmen. Abh. geol. Reichsanst., I, Abth. I, pp. IV+72, 21 text figs., 1 map.

1855.1 Arbeit über die Kreide-Schichten am Wolfgang-See; Geologisches über NW.-Mähren; vollständiges Dinotherium giganteum; Blätter-Kohle zu Böhmisch-Leipa. Neues Jahrb. Min., pp. 53, 54.

Revilliod, Pierre

1922.1 Sur un crâne de Mastodonte de Bolivie. Eclogæ geol. Helvetiæ, XVII, No. 3, December, pp. 357, 358.
Mastodon of Desaguadero.

1931.1 Sur un Mastodon de Bolivie. Mém. Soc. pal. Suisse, LI, pp. 1–21, Pls. I, II, text figs. 1–9.
New genus: *Teleobunomastodon*, p. 21, for "le Mastodonte de la Desaguadero," found in the terraces of the Desaguadero River.

Reyes, Alicia E.

1923.1 Los Elefantes de la Cuenca de Mexico. Revista Mexicana Biol., III, No. 6, August, pp. 227–244, text figs. 1–16.
Elephas columbi, E. imperator, E. hayi.

Richardson, John

1854.1 The Zoology of the Voyage of H. M. S. Herald, . . . Vertebrals, including Fossil Mammals. 4to, London, pp. xi+171, 33 pls.
New species: *Elephas Rupertianus*, found at Swan River, in Rupert's Land, Canada, Lake Winnipeg basin, pp. 101, 102, 141.

Rogers, A. W.

1907.1 Geological Survey of Parts of Bechuanaland and Griqualand West. 11th Ann. Rept. Geol. Comm., for 1906, Cape Town, pp. 7–85, text figs. 1–12.

Roman, Frédéric, Charles Depéret, and Lucien Mayet

1923.1 See Depéret, Charles, Lucien Mayet, and Frédéric Roman.

Romer, Alfred Sherwood

1928.1 Pleistocene Mammals of Algeria. Fauna of the Paleolithic Station of Mechta-el-Arbi. Bull. Logan Mus., I, No. 2, pp. 80–163.

Proboscidea, pp. 102–104. Mastodons present in the deposits of Bizerte and at St. Arnaud; localities given where the following have been found: *Elephas planifrons, E. meridionalis, E. atlanticus, E.* cf. *melitensis, E. jolensis, E. africanus.*

Roosevelt, Theodore, and Edmund Heller

1914.1 Life-Histories of African Game Animals. R.8vo, New York, I, pp. xxviii+420, 25 illustrations and 11 maps; II, pp. x+798, 25 illustrations, and 29 maps.

First use of the form *Loxodonta africana africana*, II, p. 739.

Rouault, Marie

1858.1 Note sur les Vertébrés fossiles des terrains sédimentaires de l'ouest de la France. Compt. Rend. Acad. Sci., XLVII, pp. 99–103. Paris.

Proboscidea, p. 100.

Rozier, François

1773.1 Description d'une Dent Fossile. Observ. et Mem. sur la Physique . . . (continued as Journ. Phys.), I, Fevrier, pp. 135, 136, Pl. I, figs. 1, 2.

Tooth of *Dinotherium* discovered in Dauphiny near Vienne, described and figured by l'Abbé Rozier, but not named.

Ruffer, Armand, and René Fourtau

1918.1 See Fourtau, René, and Armand Ruffer.

Rütimeyer, Ludwig

1888.1 Ueber einige beziehungen zwischen den Säugethierstämmen alter und Neuer Welt. Abh. schweiz. pal. Ges., XV, 63 pp. (unnumbered), Pl. I.

Suggests African centers of radiation [cf. Osborn, 1900.187].

Sanna-Solaro, J.-M.

1864.1 Mémoire sur le premier bassin de Dinotherium découvert dans le département de la Haute-Garonne. 4to, Toulouse, 19 pp., 3 pls. See also L'Institut, Sci. Math. Phys., No. 1605, p. 319. (Not seen by the present author.)

Discovery of a pelvis at Escanecrabe.

Sanderson, George P.

1907.1 Thirteen Years Among the Wild Beasts of India. Their Haunts and Habits from personal observation; with an Account of the Modes of Capturing and Taming Elephants. 6th edition, 8vo, Edinburgh, pp. xv+387, 24 illustrations from original drawings. The 7th edition was published in 1912.

See especially p. 55 for height of Indian elephant.

Sandford, Kenneth Stuart

1925.1 The Fossil Elephants of the Upper Thames Basin. Quart. Journ. Geol. Soc. London, LXXXI, Pt. I, Mar. 25, pp. 62–86, Pls. III–VI.

Use of the method of calculating molar length and lamellar frequency; figures molars of *Elephas antiquus, E. trogontherii*, and *E. primigenius* found in the Upper Thames basin, especially of the Handborough Terrace, 90 to 100 feet above river-level. [Compare Osborn, 1931.858 (with Colbert), on enamel length.]

Sanson, André

1869.1 Nouvelle détermination des espèces chevalines du genre Equus. Compt. Rend. Acad. Sci., LXIX, No. 23, December, pp. 1204–1207. Paris.

Equus caballus africanus.

Satō, Denzo

1914.1 Preliminary Note on the Tetrabelodon(?) from the Miocene of the Province of Mino. Journ. Geogr., XXVI (in Japanese), pp. 21–28, 2 text figs. Tokyo.

Schinz, Heinrich Rudolf

1824.1 Naturgeschichte und Abbildungen der Säugethiere. 4to, Zurich, pp. vi+417; Atlas, 177 pls.

Two of the plates are of *Elephas indicus* and one of *E. africanus.*
New species: *Mastodon turicense* [name only], p. 278.

1833.1 Ueber die Ueberreste organischer Wesen, welche in den Kohlengruben des Cantons Zürich bisher aufgefunden wurden. Denk. schweiz. Ges. Naturw., I, Abth. 2, pp. 39–64, Taf. I, II.

Mastodon turicense, description and type figure, Taf. I.

Schlegel, Hermann

1861.1 Bijdrage tot de Geschiedenis van de Olifanten, voornamelijk van Elephas sumatranus. Versl. Med. Akad. Wet., Twaalfde Deel, pp. 101–112. Amsterdam.

For English translation of this paper, with note by Sclater, see Philip Lutley Sclater, 1862.1.

Schlesinger, Günther

1911.1 Über den Fund einer pliozänen Elefantenstammform (Elephas cf. planifrons Falc.) in Niederösterreich. Monatsbl. Ver. Landeskunde v. Niederöster., V, No. 16, April, pp. 241–244.

New species: *Elephas primus*, p. 244.

1912.1 Studien über die Stammesgeschichte der Proboscidier. Jahrb. geol. Reichsanst., LXII, Heft I, pp. 87–182, Taf. VI, VII, text figs. 1–10. Wien.

Phylogeny and environment.

1913.1 Ein neuerlicher Fund von Elephas planifrons in Niederösterreich. (Mit Beiträgen zur Stratigraphie der Laaerberg- und Arsenalterrasse). Jahrb. geol. Reichsanst., LXIII, Heft IV, pp. 711–742, Taf. XXVII, XXVIII, text figs. 1–6. Wien.

Tetrabelodon (Zygolophodon) tapiroides, and *T.* (*Zyg.*) *Borsoni* [referred by the present author to *Turicius tapiroides* and *T. virgatidens* respectively].

1916.1 Meine Antwort in der Planifrons-Frage. I. Die Herkunft des Elephas antiquus. Centralb. Min. Geol. Pal., Nos. 2 and 3, pp. 32–70, text figs, 1, 1b, 2a, 2b.

1916.2 Meine Antwort in der Planifronsfrage. II. Die niederösterreichischen Planifronsmolaren. Jahrb. geol. Reichsanst., LXVI, Heft I, pp. 93–136, text figs. 1–14. Wien.

1917.1 Die Mastodonten des K. K. Naturhistorischen Hofmuseums. Denk. Naturhist. Hofmus., I, Geol.-Pal. Reihe I, pp. VII–XIX, 1–230, Taf. I–XXXVI, text figs. 1–9.

[illegible] *Mastodon (Bunolophodon) angustidens* Cuv. ? [illegible] *longirostre* Kaup *subdentidens, M.* (*Bun.*) *grandincisivum.*

1918.1 Ein wort zu W. O. Dietrichs Kritik meiner Mastodon-Rekonstruktion. Naturw. Wochenschr., N.F., XVII, No. 49, p. 704.

Reconstruction of *Mastodon angustidens* Cuv.

1919.1 Die stratigraphische Bedeutung der europäischen Mastodonten. Mitt. Geol. Ges. Wien, XI, pp. 129–166, Taf. II–VII.

New subspecies: *Mastodon americanus* Pennant *forma praetypica.* Review of *Mastodon pentelici.*

1922.1 Die Mastodonten der Budapester Sammlungen. Geol. Hungarica, Editio Separata, II, Fasc. 1, 284 pp., 22 Taf., 3 text figs.

Supplementary description of *Mastodon americanus* Pennant *forma praetypica, Mastodon* (*Bun.*) *grandincisivus*; reviews *Mastodon* (*Choerolophodon*) *pentelici.*

Schlosser, Max

1903.1 Die fossilen Säugethiere Chinas nebst einer Odontographie der recenten Antilopen. Abh. bayer. Akad., II Cl., XXII, Abth. 1, pp. 1–221, Taf. I–XIV, 32 text figs.

New species: *Mastodon Lydekkeri*, p. 46.

1905.1 Review of Andrews' 'Notes on an Expedition to the Fayûm, Egypt, with Descriptions of some New Mammals (The Geol. Mag., Decade V. 10. 1903. 337–343. 3 Fig.).' Neues Jahrb. Min. I, pp. 156, 157 (Referate).

1911.1 Beiträge zur Kenntnis der Oligozänen Landsäugetiere aus dem Fayum: Ägypten. Beitr. Pal. Geol. Österr.-Ung., XXIV, pp. 51–167, Taf. IX–XVI. Wien.

New species: *Maritherium Andrewsi.*

Schlotheim, Ernst Friedrich von

1820-1823 Die Petrefactenkunde auf ihrem jetzigen Standpunkte durch die Beschreibung seiner Sammlung versteinerter und fossiler Überreste des Thier-und-Pflanzenreichs der Vorwelt erläutert, pp. lxii+437. Nachträge, 1822, pp. xi+100; 1823, pp. 114. Gotha.

New species: *Elephas jubatus.*

Schmidtgen, O.

1926.1 Über Elephas trogontherii Pohl. Palaeont. Zeitschr., VIII, pp. 62–68, text figs. 1–3.
Discussion by W. Freudenberg and others, pp. 68–70.

Scholl, Johann Baptist, and Johann Jacob Kaup

1832.1 See Kaup, Johann Jacob, and Johann Baptist Scholl.

Schouteden, Henri

1914.1 L'Éléphant nain du Lac Léopold II (Congo). Rev. Zool. Africaine, III, Fasc. 2, pp. 391–397, Pls. xi, xii. Bruxelles.
New subspecies: *Elephas africanus Fransseni.*

Schuchert, Charles

1905.1 The Nomenclature of Types in Natural History. Science, N.S., XXI, No. 545, June 9, pp. 899–901.

1905.2 Introduction—Catalogue of the Type Specimens of Fossil Invertebrates in the Department of Geology, United States National Museum. Bull. U. S. Nat. Mus., No. 53, Pt. I, pp. 5–18.
Principles of nomenclature.

Schuchert, Charles, and Richard Swann Lull

1914.1 Mammut Americanum in Connecticut; by Charles Schuchert. With a Note on the Farmington specimen by Richard S. Lull. Amer. Journ. Sci., (4), XXXVII, pp. 321–330.

Schultz, Charles Bertrand, and Alvin L. Lugn

1934.1 See Lugn, Alvin L., and Charles Bertrand Schultz.

Schultze, Leonhard

1907.1 Aus Namaland und Kalahari. 4to, Jena, pp. xiv+752, 25 Taf., 286 text figs., 1 map.
Elephas africanus, pp. 269, 270, 452.

Sclater, Philip Lutley

1862.1 The Sumatran Elephant. By Prof. H. Schlegel. Nat. Hist. Rev., II, pp. 72–78.
Translation of Schlegel, 1861. For original paper in the Dutch language, see Schlegel, 1861.1.

Sclater, William Lutley

1900.1 The Mammals of South Africa, I, II. 8vo, R. H. Porter. London.
For Proboscidea, see Vol. I, Primates, Carnivora, and Ungulata, pp. 316–324.

Sclater, William Lutley, and Philip Lutley Sclater

1899.1 The Geography of Mammals. 8vo, London, pp. xviii+335.
Elephants, pp. 284–286.

Scott, Robert, and Henry George Liddell

1883.1 See Liddell, Henry George, and Robert Scott.

Scott, William Berryman

1895.1 Mammalia of the Deep River Beds. Trans. Amer. Phil. Soc., N. S., (2), XVIII, Pt. II, pp. 55–185, Pls. i–vi, map.
Stratigraphically important as (p. 179) "some vertebræ and fragments of limb bones, which doubtless belong to this species [*Mastodon proavus*], confirm Cope's statement that this is the oldest horizon [Deep River beds of Montana, Upper Miocene, subsequently referred to the Middle Miocene] containing *Mastodon* which has yet been found in America."

1907.1 A Collection of Fossil Mammals from the Coast of Zululand. 3d Rept. Geol. Surv. Natal and Zululand, May, pp. 253–262, Pls. xvi–xviii.
New species: *Elephas (Loxodon) zulu.*

1913.1 A History of Land Mammals in the Western Hemisphere. 8vo, The Macmillan Company, New York, pp. xiv+693, 32 pls., 304 text figs.

Seba, Albert

1734.1 Locupletissimi Rerum Naturalium Thesauri. Amstelædami [Amsterdam], I, 207 pp., 111 Tab., 2 full-page frontispieces.
Foetus Elephantis Africani ineditus, p. 175, Tab. cxi.

Seguenza, Luigi

1904.1 Intorno ad alcuni molari elefantini fossili di Sicilia e di Calabria. Riv. ital. Pal., X, pp. 41–58, Tav. i.

Sellards, Elias Howard

1913.1 Origin of the Hard Rock Phosphate Deposits of Florida. Florida State Geol. Surv., 5th Ann. Rept., pp. 23–80, Pls. i–ix, and map.

1916.1 Fossil Vertebrates from Florida: A New Miocene Fauna; New Pliocene Species; the Pleistocene Fauna. Florida State Geol. Surv., 8th Ann. Rept., pp. 77–119, Pls. x–xiv.
Mammut progenium, p. 95.

Serres, Pierre Marcel Toussaint de, and François Louis Paul Gervais

1846.1 See Gervais, François Louis Paul, and Pierre Marcel Toussaint de Serres.

Shattuck, George Burbank

1904.1 Geological and Paleontological Relations, with a Review of Earlier Investigations. Maryland Geol. Surv., Miocene, pp. xxxiii–cxxxvii, Pls. i–ix.

Shattuck, George Burbank, William Bullock Clark, and William Healey Dall

1904.1 See Clark, William Bullock, George Burbank Shattuck, and William Healey Dall.

Sherborn, Charles Davies

1898.1 Dates of Blainville's 'Osteographie.' Ann. Mag. Nat. Hist., (7), II, p. 76.
Livraison 16, *Elephas*, pp. 1–367; Livr. 17, *Dinotherium*, pp. 1–64, both of date 1845.

1902.1 Index Animalium. Sectio Prima (1758–1800). 8vo, Cantabrigiæ E Typographio Academico, pp. lix+1195.
Elephas indicus, p. 486; *E. mammonteus*, p. 582, *E. maximus*, p. 596; *E. primigenius*, p. 776.

1922–1933 Index Animalium. Sectio Secunda (1801–1850). 8vo, British Museum, London, Pts. I–XXVIII, pp. cxxxi+7056 (1922–1932); Epilogue, Additions to Bibliography, Additions and Corrections, Index to Trivialia, Pts. XXIX–XXXIII, pp. cxlvii+1098 (1933).
Elephas affinis, 1922, Pt. I, p. 124.
Harpagonotherium canadense, Fischer de Waldheim, 1808 (*fide* Sherborn, 1924, Pt. V, p. 1022).
Elephas gigas, 1926, Pt. XI, p. 2699.
Elephas mammouth, 1928, Pt. XV, p. 3845.
Elephas socotrus, 1930, Pt. XXIV, p. 6010.

Shimek, Bohumil

1909.1 Aftonian Sands and Gravels in Western Iowa. Bull. Geol. Soc. Amer., XX, pp. 399–408, Pls. xxxiii–xxxvii.

1910.1 Geology of Harrison and Monona Counties. Iowa Geol. Surv., XX, for 1909, pp. 273–485, Pls. xxi–xli, text figs. 29–37, 2 maps.
Proboscidea, pp. 323–327, Pl. xxvi.

1910.2 Evidence that the Fossiliferous Gravel and Sand Beds of Iowa and Nebraska are Aftonian. Bull. Geol. Soc. Amer., XXI, pp. 119–140, Pl. ii.
Aftonian horizon of Cox pit, from which Shimek records *Elephas imperator, E. columbi*, and *Mammut americanum.*

Simionescu, Ioan

1930.1 Elephas trogontherii Pohl. în România. Acad. Romană, Mem. Sect. Stiintifice, (III), VII, Mem. 3, pp. 25–31, Pl. i, text figs. 1–4. Bucharest.

Simpson, George Gaylord

1930.1 Tertiary Land Mammals of Florida. Bull. Amer. Mus. Nat. Hist., LIX, Art. III, pp. 149–211, text figs. 1–31.
New species: *Pliomastodon sellardsi.*

1931.1 A New Classification of Mammals. Bull. Amer. Mus. Nat. Hist., LIX, Art. V, pp. 259–293.
Bunomastodontidæ Osborn, 1918, invalid (=Palæomastodontidæ Andrews, 1906,=Trilophodontidæ auct.), p. 281. Mastodontidæ Gray, 1821 (=Mammutinæ Hay, 1930), p. 281.

1932.1 Fossil Sirenia of Florida and the Evolution of the Sirenia. Bull. Amer. Mus. Nat. Hist., LIX, Art. VIII, pp. 419–503, text figs. 1–23.

1933.1 Glossary and Correlation Charts of North American Mammal-Bearing Formations. Bull. Amer. Mus. Nat. Hist., LXVII, Art. III, pp. 79–121, figs. 1–8.

Sinclair, William John

1915.1 Additions to the Fauna of the Lower Pliocene Snake Creek Beds (Results of the Princeton University 1914 Expedition to Nebraska). Proc. Amer. Phil. Soc., LIV, No. 217, May–July, pp. 73–95, text figs. 1–18.
Gomphotherium sp.? and *Mastodon* sp.?

Sismonda, Eugenio

1851.1 Osteografia di un Mastodonte Angustidente. Mem. Accad. Sci. Torino, (2), XII, pp. 1–63, Tav. i–vi.

Sloane, Hans

1729.1 An Account of Elephants Teeth and Bones found under Ground. Phil. Trans. Roy. Soc. London, XXXV, for July to December, 1727, and for the year 1728: Pt. I, No. 403, pp. 457–471, Pl. I, figs. 1–3, Pl. II, figs. 4–7; Pt. II, No. 404, pp. 497–514.
Brief account of fossil remains unearthed at Burg-Tonna, p. 508.

Smith, Grafton Elliot, Charles Dawson, and Arthur Smith Woodward

1913.1 See Dawson, Charles, Arthur Smith Woodward, and Grafton Elliot Smith.

Smith, J. A., William Cooper, and James Ellsworth DeKay

1831.1 See Cooper, William, J. A. Smith, and James Ellsworth DeKay.

Smith, John

1847.1 Notice of the occurrence of the Elephas primigenius at Gozo near Malta. Quart. Journ. Geol. Soc. London, III (or Pt. I, Proc. Geol. Soc.), p. 52.

Smith, William

1816.1 Strata identified by Organized Fossils. 4to, London, No. 1, June 1, 32 pp., frontispiece, 3 pls.
Whitlingham tooth, opalized.

Soemmerring, Samuel Thomas von

1818 [1821] Bemerkungen über einige in der Naturaliensammlung der k. Akademie d. W. befindliche fossile Zähne von Elefanten, Mastodonten, Rhinoceros'n und einem Tapire. Denk. bayer. Akad. Wiss., München, for the years 1818, 1819, 1820, VII, pp. 17–40, Tab. I, II.

Soergel, Wolfgang

1912.1 Das Aussterben Diluvialer Säugetiere und Die Jagd des Diluvialen Menschen. Festschr. XLIII Allg. Versamml. deutsch. Anthrop. Ges. Weimar, Aug. 4–8, Heft II, 81 pp., 3 Taf. G. Fischer, Jena.

1912.2 Elephas trogontherii Pohl. und Elephas antiquus Falc. ihre Stammesgeschichte und ihre Bedeutung für die Gliederung des deutschen Diluviums. Palaeontogr., LX, pp. 1–114, Taf. I–III, Tab. I–VIII, text figs. 1–14.

1914.1 Die diluvialen Säugetiere Badens. Mitt. Grossh. badisch. geol. Landesanst., IX, Heft I, pp. 1–254, Taf. I–V. Heidelberg.
Proboscidea, pp. 62–103, Taf. IV, V.

1915.1 Die Stammesgeschichte der Elephanten. Centralb. Min. Geol. Pal., Nos. 6, 7, 8, 9, pp. 179–188, 208–215, 245–253, 278–284.

1915.2 Das vermeintliche Vorkommen von Elephas planifrons Falc. in Niederösterreich. Palaeont. Zeitschr., II, Heft I, pp. 1–65, text figs. 1–12.

1916.1 Die pliozänen Proboszidier der Mosbacher Sande. Jahresb. und Mitt. Oberrhein. geol. Ver., N. F., V, Heft II, pp. 155–161, Taf. VII, text figs. 1, 2. Stuttgart.
Elephas meridionalis and *Mastodon arvernense*.

1917.1 Zur Abstammung des Elephas antiquus Falc. Centralb. Min. Geol. Pal., pp. 213–232, text figs. 1, 2; pp. 254–266, text fig. 3.

1921.1 Die Planifrons-Frage. Neues Jahrb. Min., Beilage-Band XLIV, May 14, pp. 460–514, text figs. 1–7.

1921.2 Elephas Columbi Falconer. Ein Beitrag zur Stammesgeschichte der Elefanten und zum Entwicklungsmechanismus des Elefantengebisses. Geol. Pal. Abh., N.F., XIV, Hefte I, II, Oct. 5, pp. 1–100, Taf. I–VIII, text figs. 1–7. Jena.

1926.1 Exkursion ins Travertingebiet von Ehringsdorf. Palaeont. Zeitschr., VIII, Hefte I, II, pp. 7–33, Taf. I.

1929.1 Das Alter der Sauerwasserkalke von Cannstatt. Jahresb. und Mitt. Oberrhein. geol. Ver., pp. 93–153, Taf. I, II, text figs. 1–10.
See p. 95 for *Elephas trogontherii*, also Taf. I.

Spillmann, Franz

1928.1 Tetrabelodon Nov. Spec. Ayora-Spillm. El Ecuador Comercial, Año VI, March, No. 57. Quito, Ecuador.
Unsigned article, but believed to be the first mention of the species *Bunolophodon ayoræ* of Spillmann, also of the "Mastodonte de Alangasi" [= *Cuvieronius posteremus*].

1928.2 El Mastodonte de Alangasi. El Ecuador Comercial, Año VI, March, No. 57, pp. 74, 75. Quito, Ecuador.
Unsigned article.

1929.1 Das letzte Mastodon von Südamerika. Natur und Museum, LIX, Heft II, February, pp. 119–123, text figs. 1–4.
"Mastelon aus Alangasi."

1929.2 Das südamerikanische Mastodon als Zeitgenosse des Menschen majoiden Kulturkreises. Palaeont. Zeitschr., XI, Nr. 2, July 22, pp. 170–177, text figs. 1–4.
"Mastodon aus Alangasi."

1931.1 Die Säugetiere Ecuadors im Wandel der Zeit. 8vo, Univ. Central, Quito, Ecuador, Erster Teil, 112 pp., 25 figs.
Supplementary description of *Bunolophodon* [*Cuvieronius*] *ayoræ* (p. 67) and *Bunolophodon* [*Cuvieronius*] *posteremus* (p. 73).

Spock, Leslie Erskine

1929.1 Pliocene Beds of the Iren Gobi. Amer. Mus. Novitates No. 394, Dec. 26, 8 pp., 6 text figs.
Horizon name Tung Gur derived by reversing Gur Tung (Gur Tung Khara Usu being the name of an important well).

Stanley, George M.

1935.1 See Case, Ermine Cowles, and George M. Stanley.

Stauffer, Clinton Raymond

1924.1 The Fossil Elephants of Minnesota. Science, N.S., LX, No. 1541, July 11, pp. 40, 41.

Stearns, Robert Edwards Carter

1873.1 [Report of a fossil elephant tooth found on Santa Rosa Island.] Proc. Calif. Acad. Sci., V, p. 152.

Stefănescu, Gregoriŭ

1878.1 Découverte d'une molaire de Dinothérium en Roumanie. Ann. Soc. Acad. Roumanie, (1), XI, pp. 101–104, 2 figs.
Original not available.

1892.1 On the Existence of the Dinotherium in Roumania. Bull. Geol. Soc. Amer., III, pp. 81–83, text fig. 24.
New species: *Dinotherium gigantissimum*.

1895.1 Dinotherium gigantissimum. Anuar. Mus. Geol. Pal., for the year 1894, pp. 126–199, Tab. I–V.

1899.1 Dinotherium gigantissimum Stef. Anuar. Mus. Geol. Pal., pp. 110–145, Tab. I–V, text figs. 1–6.

1910.1 Dinotherium gigantissimum. Anuar. Muzeului Geol. Paleont., IV, pp. 1–43, Tab. I–XII. Bucharest.

Stefănescu, Sabba

1918.1 Sur une nouvelle voie à suivre pour l'étudier la phylogénie des mastodontes, stégodontes et éléphants. Compt. Rend. Acad. Sci., CLXVI, pp. 739–741. Paris.

1919.1 Sur les fosses alvéolaires, les périodontes, les loges alvéolaires et les alvéoles des éléphants et des mastodontes. Compt. Rend. Acad. Sci., CLXIX, pp. 148–151. Paris.

1924.1 Sur la Présence de l'Élephas planifrons et de trois mutations de l'Elephas antiquus dans les couches géologiques de Roumanie. Compt. Rend. Acad. Sci., CLXXIX, pp. 1418, 1419. Paris.
New subspecies: *Elephas antiquus rumanus* and *E. antiquus germanicus*.

1927.1 30 Notes sur l'Organisation des Molaires et sur la Phylogénie des Éléphants et des Mastodontes. Présentées à l'Académie des Sciences Paris de 1913 à 1924 et accompagnées de 80 planches démonstratives. 4to, Univ. Bucarest, Laboratoire de Paléontologie, 101 pp., 80 pls.
The text appeared in the Comptes Rendus hebdomadaires des séances de l'Académie des Sciences (Paris), without plates.

Stehlin, Hans Georg

1899-1900 Ueber die Geschichte des Suiden-Gebisses. Abh. schweiz. pal. Ges., XXVI, Erster Teil (1899), pp. V–VII, 1–336; XXVII, Zweiter Teil (1900), pp. 337–527. Zurich.
African origin of European fauna, XXVII, pp. 478–488.

1926.1 Über Milchincisiven miocäner Proboscidier. Eclogæ geol. Helvetiæ, XIX, No. 3, pp. 693–700, text figs. 1–5.

1930.1 Die Säugetierfauna von Leffe (Prov. Bergamo). Eclogæ geol. Helvetiæ, XXIII, No. 2, pp. 648–681, text figs. 1–9.
Elephas meridionalis, p. 650, *Elephas antiquus*, p. 673, *Mastodon arvernensis*, p. 674.

Sternberg, Charles Hazelius

1903.1 Elephas columbi and Other Mammals in the Swamps of Whitman County, Washington. Science, N.S., XVII, No. 430, Mar. 27, pp. 511, 512.

Skull of *Elephas columbi* [= *Parelephas washingtonii* ref.]

Sternberg, Charles M.

1930.1 New Records of Mastodons and Mammoths in Canada. Canad. Field-Naturalist, XLIV, March, pp. 59–65, 1 pl., 1 map.

Sternberg, George F., and Erwin Hinckley Barbour

1935.1 See Barbour, Erwin Hinckley, and George F. Sternberg.

Stirton, Ruben Arthur

1934.1 A New Species of Amblycastor from the Platybelodon Beds, Tung Gur Formations, of Mongolia. Amer. Mus. Novitates, No. 694, Feb. 21, 4 pp., 6 text figs.

Stirton, Ruben Arthur, and Paul O. McGrew

1935.1 A Preliminary Notice on the Miocene and Pliocene Mammalian Faunas near Valentine, Nebraska. Amer. Journ. Sci., (5), XXIX, No. 170, February, pp. 125–132.

Stock, Chester

1935.1 Exiled Elephants of the Channel Islands, California. Sci. Monthly, September, pp. 205–214, figs. 1–9.

Archidiskodon exilis and *E. imperator*.

Stock, Chester, and Eustace L. Furlong

1928.1 The Pleistocene Elephants of Santa Rosa Island, California. Science, N.S., LXVIII, No. 1754, Aug. 10, pp. 140, 141.

New species: *Elephas exilis*.

Strauss, Friedrich Carl Joseph von

1837.1 Considérations sur le genre de vie du Dinotherium et sur la place qu'il convient de lui assigner dans une distribution naturelle des mammifères. Compt. Rend. Acad. Sci., IV, pp. 529–532. Paris.

Dinotherium an aquatic animal.

Stremme, Herman

1911.1 Die Säugetiere mit Ausnahme der Proboscidier. In "Die Pithecanthropus-Schichten Auf Java." Herausgegeben vom M. Lenore Selenka und Prof. Max Blanckenhorn, pp. 82–150, Taf. xvi-xx, text figs. 1–10.

See especially pages 142–148.

Stromer, Ernst

1903.1 Ueber Afrika als Entstehungszentrum für Säugetiere. Zeitschr. deutsch. geol. Ges., LV, Protokoll, pp. 61–67.

1934.1 Gibt es zeitgenössische Abbildungen von Mastodonten? Palaeont. Zeitschr., XVI, June 30, pp. 85–90, text fig. 1.

Stur, Dionys

1864.1 Ueber die neogenen Ablagerungen im Gebiete der Mürz und Mur in Obersteiermark. Jahrb. geol. Reichsanst., XIV, pp. 218–252. Wien.

Dinotherium bavaricum, p. 226.

Suess, Eduard

1863.1 Über die Verschiedenheit und die Aufeinanderfolge der tertiären Landfaunen in der Niederung von Wien. Sitz.-Ber. Akad. Wiss., XLVII, Abth. I, pp. 306–331. Wien.

Dinotherium and *Mastodon*.

1864.1 Bericht über Mastodon-Reste von Franzensbad. Jahrb. geol. Reichsanst., XIV, Heft IV, [Verh.], December, pp. 237–239. Wien.

Sunamoto, Etsujiro

1931–1932 A Résumé of 'The Elephant,' I, II. 8vo, Osaka. Illustrated. (Published in Japanese with English translation of Table of Contents.)

A remarkable compendium of the living elephants, pp. 1917–1929. Mammoth and prehistoric proboscideans, pp. 1930–1945.

Szalay, Tibor, and Julius Éhik

1930.1 See Éhik, Julius, and Tibor Szalay.

Targioni-Tozzetti, Giovanni

1775.1? Relazioni d'alcuni Viaggi fatti in diverse parti della Toscana per osservare le Produzioni naturali e gli antichi Monumenti di essa. Firenze, 1751–1754, 6 volumes, 8vo; 1768–1779, 12 volumes, 8vo, (Germ. C. J. Jagemann): Reisen durch verschiedene Gegenden des Gross-Herzogthums Toskana, in einem Auszuge. Leipz. 1787, 2 volumes, 8vo.—Böhm, Bibl. I, 1, p. 564.—(Gall.) Voyage minéralogique, philosophique et historique en Toscane. Par. 1792, 2 volumes, 8vo.

Elefante Indiano, Ed. 2ª (1768–1779), Vol. VIII, Firenze, 1775?, p. 391 *et seq.* (reference *fide* Weithofer, 1890, p. 133).

Temminck, Coenraad Jacob

1847.1 Coup-d'œil général sur les possessions Néerlandaises dans l'Inde Archipélagique. Leiden, I–III (1846–1849).

New species: *Elephas sumatranus*, Vol. II, p. 91.

Teilhard de Chardin, Pierre, and Chung-Chien Young

1931.1 Fossil Mammals from the Late Cenozoic of Northern China. Geol. Surv. China, Palaeont. Sinica, (C), IX, Fasc. 1, pp. 1–88, Pls. i–x, text figs. 1–23, sketch map; also 5 pages in Chinese.

Mastodon sp., p 56, Pl. viii, fig. 101.

Tentzelius, Wilhelmus Ernestus (William Ernest Tentzel)

1698.1 Wilhelmi Ernesti Tentzelii Historiographi Ducalis Saxonici Epistola de Sceleto Elephantino Tonnæ nuper effosso, ad Virum toto orbe celeberrimum Antonium Magliabechium, Serenissimi Magni Hetruriæ Ducis Bibliothecarium & Consiliarium. Phil. Trans. Roy. Soc. London, XIX, for the years 1695, 1696, and 1697, No. 234, November, pp. 757–776.

The classic Burg Tonna skeleton, subject of controversy between Tentzelius and Medical Faculty of Gotha [see Vol. II, Chap. XVIII of the present Memoir].

Terra, Paul de

1911.1 Vergleichende Anatomie des menschlichen Gebisses und der Zähne der Vertebraten. 8vo, G. Fischer, Jena, pp. xiii + 451, 200 text figs.

Proboscidea, pp. 333–338.

Theobald, William

1860.1 On the Tertiary and Alluvial deposits of the central portion of the Nerbudda Valley. Mem. Geol. Surv. India, II, Pt. II, pp. 279–298, 1 text fig.

For fossiliferous deposits, see page 280. *Elephas Ganesa* (?) below Birman Ghat near village of Bilthari; *Elephas Namadicus* near village of Patrora.

Thevenin, Armand

1920.1 See Boule, Marcellin, and Armand Thevenin.

Thomas, Michael Rogers Oldfield

1893.1 Suggestions for the more definite use of the word "Type" and its compounds, as denoting Specimens of a greater or less degree of Authenticity. Proc. Zool. Soc. London, March 14, pp. 241, 242.

1911.1 The Mammals of the Tenth Edition of Linnæus; an Attempt to fix the Types of the Genera and the exact Bases and Localities of the Species. Proc. Zool. Soc. London, pp. 120–158.

Genus *Elephas*, "Type *E. maximus* (*E. indicus auctorum*)." Type locality: Ceylon.

Thomas, Philippe

1884.1 Recherches Stratigraphiques et Paléontologiques sur Quelques Formations d'Eau Douce de L'Algérie. Mém. Soc. géol. France, (3), III, No. 2, pp. 1–51, Pls. vii–x.

Tilesius von Tilnau, Wilhelm Gottlieb

1815.1 De Skeleto Mammonteo Sibirico ad maris glacialis littora anno 1807, effosso, Cui Praemissae Elephantini Generis Specierum Distinctiones. Sectio Primo. . . . Conventui exhibuit die 10 Jan. 1810. Mém. Acad. Imp. Sci. St. Péterbs., (V), V, for 1812, pp. 406–513, Tab. x, xi.

Description of the "Adams skeleton," with figure.

Tokunaga [Yoshiwara], Shigeyasu

1906.1 Fossils from the Environs of Tokyo. Journ. Coll. Sci., Imp. Univ. Tokyo, XXI, Art. II, pp. 1–96, 6 pls.

1933.1 Fossil Elephants found in Tokyo. Journ. Geog., XLV, No. 535, pp. 419–426, Pls. v, vi.

Elephas indicus Buski, *Palæoloxodon namadicus*, *Loxodonta naumanni*, *Palæoloxodon* sp.

Tolmachoff, Innokenty Pavlovich

1928.1 Extinction and Extermination. Bull. Geol. Soc. Amer. XXXIX, Dec. 30, pp. 1131–1148.
The Mammoth, pp. 1136, 1137.

1929.1 The Carcasses of the Mammoth and Rhinoceros Found in the Frozen Ground of Siberia. Trans. Amer. Phil. Soc., N.S., XXIII, Pt. I, Art. I, pp. i–x, 11–74, map.

Trouessart, Édouard Louis

1897-1899 Catalogus Mammalium Tam Viventium Quam Fossilium. Nova Editio (Prima Completa), 8vo, Berolini [Berlin], pp. v+1264, Appendix, pp. 1265–1469.
Proboscidea, pp. 699–711.

1904-1905 Catalogus Mammalium Tam Viventium Quam Fossilium. Quinquennale Supplementum, 8vo, Berolini [Berlin], pp. vii+929.
Proboscidea, pp. 596–604.

Tullberg, Tycho Fredrik Hugo

1899-1900 Ueber das System der Nagethiere, eine Phylogenetische Studie. Nova Acta R. Soc. Sci. Upsala, 1899, (III), XVIII, Fasc. I, pp. 11–328; 1900, (III), XVIII, Fasc. II, pp. 329–514, A1-A18, Taf. I–LVII.
Theory of Africa as an evolution center, pp. 485–495, especially pp. 490, 491.

Udden, Johan August, and Netta C. Anderson

1905.1 See Anderson, Netta C., and Johan August Udden.

Uhle, Max

1930.1 Späte Mastodonten in Ecuador. Proc. Twenty-third Internat. Cong. Americanists, September, 1928, pp. 247–258, text figs. 1–10.
Confirmation of the relatively recent prehistoric age of the Mastodon of Alangasi, as evidenced by the presence of obsidian flints, carved bone implements, etc.

Unsigned articles (see under Anonymous)

Vacek, Michael

1877.1 Über Österreichische Mastodonten und ihre Beziehungen zu den Mastodonarten Europas. Abh. geol. Reichsanst., VII, Heft IV, pp. 1–45, Taf. I–VII. Wien.
New genera: *Zygolophodon* and *Bunolophodon*, p. 45.

Van der Maarel, Franciscus Hendricus

1932.1 See Maarel, Franciscus Hendricus van der.

Vaufrey, Raymond

1929.1 Les Éléphants Nains des Iles Méditerranéennes et la Question des Isthmes Pléistocènes. Arch. Inst. Pal. Humaine, Mém. VI, 220 pp., 9 pls., 45 text figs.
An exhaustive treatment of *Elephas antiquus* race *Falconeri*, race *melitensis*, race *mnaidriensis*.

Vaughan, Thomas Wayland

1924.1 Criteria and Status of Correlation and Classification of Tertiary Deposits. (Presidential Address before Paleontological Society.) Bull. Geol. Soc. Amer., XXXV, Dec. 30, pp. 677–742, 3 Correlation Tables.
Table I. Correlation of the Tertiary Formations of Europe—*Dinotherium giganteum* sands. Table III. Correlation of West Indian and Central American Tertiary Horizons (Choptank formation in Eastern United States, also p. 735).

Verri, Antonio

1886.1 Azione delle Forze nell'Assetto delle Valli con Appendice sulla Distribuzione dei Fossili nella Valdichiana e nell'Umbria Interna Settentrionale. Boll. Soc. geol. Ital., V, pp. 416–454.
Elephas primigenius, Elephas antiquus, Elephas ausonius, pp. 452, 453.

Villada, Manuel Maria

1903.1 Apuntes Acerca de la Fauna Fósil del Valle de Mexico. Ann. Mus. Nac. Mexico, VII, May, pp. 441–451, Lám. I–VIII.
Proboscidea, pp. 450, 451, two plates. Paratype figure (Lám. VIII) of *El. Columbi* var. *Falconeri* Freudenberg, 1922, figured as *El. primigenius* Blum.

Wadia, D. N.

1919.1 Geology of India. 8vo, Macmillan and Co., Ltd., London, pp. xx+381, 20 pls., 37 text figs.
Irrawaddy system, p. 213.

Wagner, Andreas

1850.1 Urweltliche Säugthier-Ueberreste aus Griechenland. Abh. bayer. Akad. Wiss., V, Abth. I, Cl. II, pp. 335–378, Tab. IX XII.
Proboscidea, pp. 360–365.

1857.1 Neue Beiträge zur Kenntniss der fossilen Säugthier-Ueberreste von Pikermi. Abh. bayer. Akad. Wiss., VIII, Abth I, Cl. II (or XXXI of the Denkschriften), pp. 111–158, Tab. III–IX.
New species: *Mastodon atticus* G. & L., p. 32.

Wagner, George

1899.1 On Tetracaulodon (Tetrabelodon) Shepardii. Cope. Kansas Univ. Quart., (A), VIII, No. 2, April, pp. 99–103, Pls. XXIV, XXV, 1 text fig.

Wallace, Alfred Russel

1876.1 The Geographical Distribution of Animals. 8vo, Macmillan and Co., London, I, pp. xxi+503; II, pp. viii+607. Illustrations and maps.
Abstract of Lund's researches in the caves of Central Brazil, "mostly situated in a district near the head waters of the San Francisco river in the Province of Minas Geraes," Vol. I, pp. 143–146.

Warren, John Collins

1852-1855 The Mastodon Giganteus of North America. 4to, Boston, pp. viii+219, 26 pls., and folding plate.
A second edition of this book was published in 1855, in which new matter was introduced, old matter corrected, and three important plates added. [The "Baltimore mastodon" tooth figured by Warren, Pl. XXVI, is not the original "Baltimore mastodon" tooth described by Harlan and referred to *M. longirostris*. See Leidy, 1858.3.]

Watson, David Meredith Seares

1929.1 Proboscidea. Encyclopædia Britannica, 14th Edition, Vol. XVIII, pp. 541–543; under Elephant, Vol. VIII, p. 349; under Mammoth, Vol. XIV, p. 756; under Mastodon, Vol. XV, p. 42.

Wayland, E. J.

1926.1 See Hopwood, Arthur Tindell, and E. J. Wayland.

Wegner, Richard Nickolaus

1908.1 Zur Kenntnis der Säugetierfauna des Obermiocäns bei Oppeln (Oberschlesien). Verh. geol. Reichsanst., Nos. 5, 6, pp. 111–117. Wien.
Mastodon sp. intermediate between *M. angustidens* and *M. longirostris*. [See Wegner, 1913.1, *Mastodon angustidens* var. *austro-germanica*.]

1913.1 Tertiaer und umgelagerte Kreide bei Oppeln (Oberschlesien). Palaeontogr., LX, pp. 175–274, Taf. IX–XV, text figs. 1–35.
New subspecies: *Mastodon angustidens* var. *austro-germanica*.

Weinsheimer, Otto

1883.1 Über Dinotherium giganteum Kaup. Geol. u. Pal. Abh., I, Heft III, pp. 207–282, Taf. XXV–XXVII. Berlin.
Excellent history of the Dinotheres.

Weithofer, K. Anton

1888.1 Einige Bemerkungen über den Carpus der Proboscidier. Morph. Jahrb., XIV, pp. 507–516.

1889.1 Ueber die tertiären Landsäugethiere Italiens. Jahrb. geol. Reichsanst., XXXIX, Heft I, pp. 55–82. Wien.
New species: *Elephas tyrsenus*, p. 80.

1890.1 Die Fossilen Proboscidier des Arnothales in Toskana. Beitr. Pal. Österr.-Ung., VIII, pp. 107–240, Taf. I–XV. Wien.
Detailed treatment of *Elephas meridionalis* and *E. tyrsenus*. Restored Cranium A of *Elephas meridionalis* Nesti [=paratype of Osborn]; figures the type skull of *Elephas tyrsenus*.

1893.1 Proboscidiani Fossili di Valdarno in Toscana. Mem. Carta Geol. Ital. R. Com. Geol. Regno, IV, Pt. II, pp. 1–152, Tav. I–XV.
Mastodon arnensis, Elephas meridionalis, E. tyrsenus, E. antiquus, E. primigenius.

Whitfield, Robert Parr

1891.1 Mastodon Remains on New York Island. Science, XVIII, No. 463, Dec. 18, p. 342.

Winge, Herluf

1906.1 Jordfundne og nulevende Hovdyr (Ungulata) fra Lagoa Santa, Minas Geraes, Brasilien. E Museo Lundii, III, Halvbind I, pp. 1–239, Pls. I–IX. Kjøbenhavn.
Mastotheriini, Dinotheriini, Elephantini, p. 172.

Witsen, Nicolaes [also written Nicolaus Witsen]

1692.1 Noord en Oost Tartarye.
This first edition is not available to the present author. According to Howorth (1882.1, p. 30) this work "has never been translated into any western language, and remains still buried to a large part of the scientific world in the original Dutch." He further states that the name Mammoth first appears in this work and is there written Mammout.
The second edition of 1705 (which is available) treats the Mammoth on pages 742–746, and confirms the name *Mammoul*. This edition consists of two parts and was published at Amsterdam by François Halma: it contains 16+968+16 pages, with illustrations. Another edition is dated 1785.

Woodward, Arthur Smith

1930.1 The Extinct Dwarf Elephants of Sicily and Malta. Nature, CXXV, No. 3142, Jan. 18, pp. 82, 83.

Woodward, Arthur Smith, Charles Dawson, and Grafton Elliot Smith

1913.1 See Dawson, Charles, Arthur Smith Woodward, and Grafton Elliot Smith.

Wortman, Jacob L., and Henry Fairfield Osborn

1892.1 See Osborn, Henry Fairfield, 1892.67.

Wüst, Ewald

1901.1 Untersuchungen über das Pliozän und das Älteste Pleistozän Thüringens. Abh. naturf. Ges. Halle, XXIII, pp. 17–352, Taf. i–ix, text figs. 1, 2, 4 Tables. Stuttgart.

Elephas primigenius-meridionalis-trogontherii.

Yabe, Hisakatsu

1929.1 The Latest Land Connection of the Japanese Islands to the Asiatic Continent. Proc. Imp. Acad. Japan, V, No. 4, pp. 167–169, text fig.

Yates, Lorenzo Gordin

1874.1 Extract of a Letter relating to Mammalian Fossils in California. Proc. Acad. Nat. Sci. Phila., XXVI, pp. 18–21.

Lists localities at which the fossil *Elephas* and *Mastodon* have been found.

Young, Chung-Chien

1935.1 Miscellaneous Mammalian Fossils from Shansi and Honan. Pal. Sinica, (C), IX, Fasc. 2, 57 pp., 7 pls., 13 text figs. Peiping (Peking).

Stegodontidæ, name only, p. 5. New species: *Stegodon officinalis* Hopwood in Young, p. 27; *Stegodon yüshensis*, p. 26; *S. zdanskyi* Hopwood in Young, p. 28. *Mastodon borsoni* molar from Yüshe.

Young, Chung-Chien, and Pierre Teilhard de Chardin

1931.1 See Teilhard de Chardin, Pierre, and Chung-Chien Young.

Zalensky, Vladimir Vladimirovich

1903.1 Zur Phylogenie der Elephantiden. Biol. Centralb., XXIII, No. 24, pp. 793–803, text fig.

1903.2 Osteological and Odontological researches on the Mammoth (Elephas primigenius Blum.) and Elephants (E. indicus L. and El. africanus Blum.). Scientific results obtained by the expedition, sent out by the Academy [Acad. Imp. Sci. St. Pétersb.] to dig for Mammoths, on the River Berezovka in 1901. I, II, Illustrated. 4to, St. Petersburg. (In Russian.) I, 124 pp., 25 pls.

Zdarsky, A., and Adolf Hofmann

1905.1 See Hofmann, Adolf, and A. Zdarsky.

Zittel, Karl Alfred von

1891–1893 Handbuch der Palaeontologie. Palæozoologie. Vertebrata (Mammalia), IV, pp. xi+799, 590 text figs. 8vo. München u. Leipzig.

1901.1 History of Geology and Palæontology. To the end of the Nineteenth Century. Translation by Maria M. Ogilvie-Gordon, D.Sc. (London), Ph.D. (Munich). 8vo, Charles Scribner's Sons, New York, pp. xiii+562, 13 portraits.

Zuffardi, P.

1913.1 Elefanti Fossili del Piemonte. Palaeont. ital., XIX, pp. 121–187, Tav. vii–xii.

New subspecies: *Elephas antiquus* Falc. var. *trogontherioides.*

Zukowsky, Ludwig

1924.1 Beitrag zur Kenntnis der Säugetiere der nördlichen Teile Deutsch-Südwestafrikas unter besonderer Berücksichtigung des Grosswildes. Arch. Naturges., XC, Abth. A, Heft I, pp. 29–164, text figs. 1–12. Berlin.

New subspecies: *Loxodonta africana Zukowskyi* Strand (in Zukowsky), p. 68.

ERRATA

Page 28, line 32, *Palæomastodon* should be removed from the Mastodontinæ; in the Appendix (p. 691) it is made the type of the new subfamily Palæomastodontinæ.

Page 29, caption to figure 6, substitute Johnston, 1898, for Johnston, 1907 (see Bibliography).

Page 160, lines 13 and 14, left column, cotypes of *Pliomastodon americanus praetypica*, substitute the following: Originals of figure 1 in the Ungarische Reichsanstalt of Budapest; of figures 2 to 5 inclusive in the Hungarian National Museum of Budapest.

Page 264, lines 24 and 27, right column, Gaudry, 1862, should read Gaudry, 1862–1867.

Page 283, lines 1 and 4, under *Trilophodon pontileviensis*, Fig. 138A, B, should read Fig. 138B.

Page 317, Fig. 272. This figure, with caption, has been corrected and is repeated as figure 679 on page 733 of the Appendix.

Page 334, supercaption to figure 286, line 3, after *Amebelodon* retain B and omit E.

Page 385, line 30 (No. 27c), *Ocalientinus emmonsi* of the marl beds of North Carolina, determined as of Pliocene age, redetermined (p. 733 of Appendix) as of Miocene age.

Page 457, bottom of right column, under *Serridentinus lydekkeri*, substitute for Shansi(?), North China, the localities Tientsin, Honan, etc., North China.

Page 484, caption to figure 454, molar from Tambla (c) is described in Leidy, 1869, p. 242, not p. 424.

Page 554, line 17, Cope, 1892.2, p. 227, should read 1892.4, p. 227 (see Bibliography).

Page 664, top of left column, Amer. Mus. 19462 is not referable to *Synconolophus dhokpathanensis* but to *S. hasnoti* (see Fig. 628, p. 660).

69°
70°
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AFGHANISTAN
BALUCHISTAN
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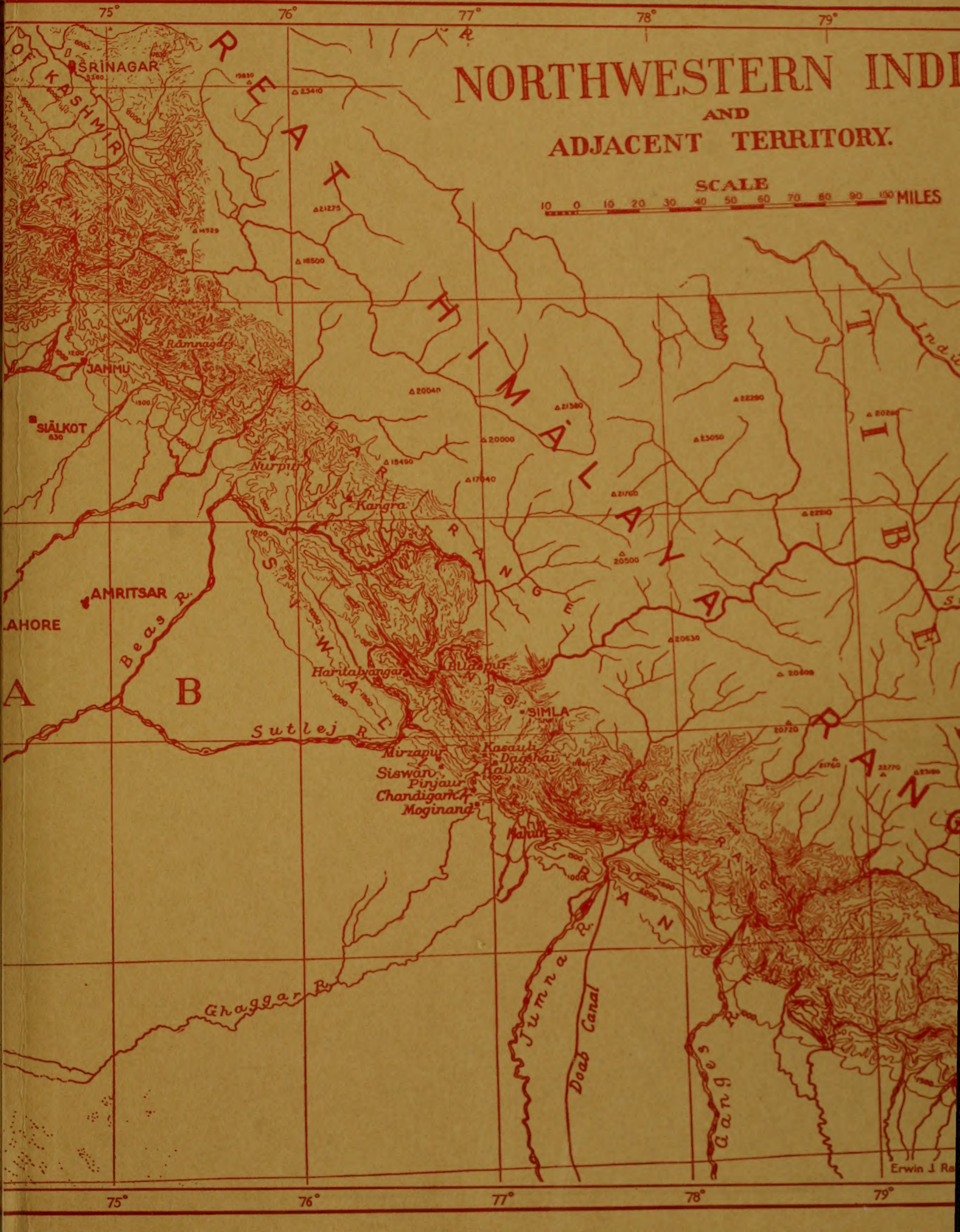
MURREE
RĀWALPINDI
1689
Khaur
Pindi Gheb
1439
BANNU
Dhok Pathān
Chakwāl
Tatrōt
Hasnot
Chinji
Chinji Bungalow
SALT RANGE
Lakki
Indus R.
Jhelum R.
Chenāb R.
Sutlej R.
Dera Ghazi Khan


NORTHWESTERN INDI
AND
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SCALE
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GREAT HIMALAYA RANGE
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Kangra
AMRITSAR
Beas R.
LAHORE
Haritalyangar
Bilaspur
SIMLA
Sutlej R.
Mirzapur
Siswan
Pinjaur
Chandigarh
Moginand
Kasauli
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Kalka
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Ghaggar R.
Jumna R.
Doab Canal
Ganges R.
Erwin J. Ra

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